GOVERNMENT OF TAMIL NADU

ZOOLOGY

HIGHER SECONDARY FIRST YEAR

VOLUME - I

Untouchability is Inhuman and a Crime

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Government of Tamil Nadu

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STROKE VOLUME IS DEPENDENT ON VENOUS RETURN

Conceptual picture with caption relating to every chapter is given in this text book.

Chapter Outline	Presents a complete overview of the chapter
Learning Objectives:	Goals to transform the classroom processes into learner centric with a list of bench marks
DO YOU KNOW?	Amazing facts, Rhetorical questions to lead students to biological inquiry
Note:	Additional inputs to content is provided
Activity	Directions are provided to students to conduct activities in order to explore, enrich the concept.
Infographics	Visual representation of the lesson to enrich learning .
CASE STUDY	Superfluous information about a personality or day to day life experience relating to the content
	To motivate the students to further explore the content digitally and take them to virtual world
ICT	To enhance digital Science skills among students
Concept Map	Conceptual diagram that depicts relationships between concepts to enable students to learn the content schematically
Glossary	Explanation of scientific terms
Evaluation	Assess students to pause, think and check their understanding
Career corner	List of professions particular to that chapter
References	List of related books for further details of the topic
Web links	List of digital resources

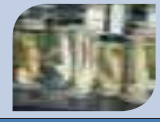
Career options in Zoology

Courses	Institutions	Professions and Scope for Future Studies
Medical course ◉ MBBS – Allopathy ◉ MD ◉ MS ◉ BUMS – Unani ◉ BNYS _ Naturopathy ◉ BHMS – Homeopathy ◉ BDS _ Dental ◉ BAMS – Ayurveda ◉ BSMS _ Siddha	► AIIMS, New Delhi ► JIPMER ► Government & Private Medical Colleges ► AFMC, AMU	Civil surgeon / Civil assistant surgeon in central and state govt hospitals and in private sector. Specialist in various medical fields like Cardiologist, Endocrinologist, Neurologist, Orthopedician, Paediatrician, Haematologist, Pathologist and Anaesthetist. ◉ Cardiology ◉ Pulmonology ◉ Nephrology ◉ Diabetology ◉ Dermatology, ◉ Anaesthesiology ◉ Ophthalmology ◉ Obstetrics and Gynaecology
Veterinary Course ◉ B. V. Sc. (Bachelor of Veterinary Sciences)	► State Veterinary Universities & Colleges	(Veterinary Surgeon/ Veterinary Assiatant Surgeon in central and state govt hospitals and in private sector). ◉ Animal Biochemistry ◉ Dairy Science ◉ Animal Biotechnology ◉ Dairy Technologisty ◉ Animal Genetics and Breeding ◉ Livestock Production Management ◉ Animal Nutrition ◉ Animal Physiology ◉ Bio-Statisticis ◉ Food Quality and Safety Assurance ◉ Poultry Science ◉ Indian Traditional Foods Preservation & Packaging ◉ Veterinary Bacteriology ◉ Veterinary Immunology
Agri Courses ◉ B. Sc. (Agriculture) ◉ B. Tech (Agriculture) ◉ B. Sc. (Horticulture) ◉ B. Sc. (Forestry) ◉ B. Sc. (Sericulture) ◉ B. F. Sc. (Bachelor of Fisheries Sciences)	► IARI, Delhi ► Agriculture Universities & Colleges	(Agriculture Officer in state and central government service and other private employment oppurtunites) ◉ Agricultural Engineer ◉ Environmental Sciences ◉ Agronomist ◉ Fruit Sciences and Horticultural Technology ◉ Bioinformatics ◉ Plant Pathology ◉ Entomologist ◉ Soil science & Agro Chemistry
Para Medical courses ◉ B. Sc. (Nursing) ◉ B. Sc. (Trauma Care Management) ◉ B. Pharm, D. Pharm ◉ BPT (Bachelor of Physiotherapy) ◉ BOT (Bachelor of Occupational Therapy) ◉ B. Optom. (Bachelor of Optometry)	► All India Institutes of Medical Sciences (AIIMS), New Delhi, Bhopal, Bhubaneswar, Jodhpur, Patna, Raipur, Rishikesh. ► JIPMER, Puducherry ► All Government & Private Medical Colleges	◉ Nursing ◉ Nuclear Medicine Technician Occupational therapist ◉ Pharmacy ◉ Operation Theatre Technician ◉ Anaesthesia Technician ◉ Ophthalmic Assistant ◉ Cardiac Technician ◉ Physiotherapst ◉ Dental Mechanic ◉ Radiographic Assistant ◉ Health Inspector ◉ Radiotherapy Technician ◉ Medical Imaging & Technician ◉ Rehabilitation Technician ◉ Medical Lab Techician ◉ Respiratory Therapy Technician ◉ Medical X-ray Technican ◉ Blood Transfusion Technician
General Courses ◉ B.Sc. Zoology ◉ B.Sc. Food Technology ◉ B.Sc. Dietician & Nutritionist ◉ B.Sc. Dairy Technology ◉ B.Sc. Sericulture ◉ B.Sc. Mass Communication ◉ B.Sc. Oceanography ◉ B.Sc. Multimedia ◉ B.Sc. Forensic Sciences ◉ B.Sc. 3D Animation	Government Arts and Science Colleges in TamilNadu	Zoo keepers, Creators, Bird watchers in Airports and Lab Technician.
Bachelor of Science and Education (BSc, B.Ed) M.phil in Education IDGC Ph.D	Regional Institute of Education (Mysore, Ajmeer, Bhopal,Bhuvaneswar), Shillong	BT.Assistant (Science teacher for secondary level)

Post graduation and Doctorate courses in National and State level institutes

*Civil Service Exams for all india services (IAS, IPS, IFoS) and other central services &*Other service exams conducted by TNPSC, IBPS, NDA, CDS, SSC and RRB.

Career options in Zoology

Master of science and Education (MSc, B.Ed) 	Regional Institute of Education (Mysore, Ajmeer, Bhopal,Bhuvaneswar)	PG.Assistant (Zoology, teachers, professors in collegeslectures and universities higher secondary level)
Master of science in Zoology	Government arts and science colleges in TamilNadu - Madras University	Researchers in variegated subjects in zoology and life science, Scientist, Environmetologyist, Dietician and Nutritionist
Master of science in Marine Zoology 	National institute of Oceanography ► Andhra University(Visakhapatnam) ► Anna University (Chennai) ► Dr. Babasaheb Ambedkar Marathwada University Marine Research Laboratory (Maharashtra) ► Bharathidasan University (Tiruchirappalli)	Career opportunities in National Marine park and Marine Engineers
Master of science in zoology with specialization in Medical Microbiology 	► Co-operative institute of health science (Kerala) ► Dolphin institute of Bio-Medical and Natural Science (Dehradun) ► Himalayan University (Arunachal Pradesh)	⊙ Lab Technician ⊙ Medical Imaging and technician ⊙ Respiratory therapy technician ⊙ Nuclear Medicine ⊙ Health Inspector ⊙ Blood transfusion technician
Master of philosophy and Ph.D in Zoology 	► State Universities	Professor, Research scholar Scientist in University , Documentarist in National Geographic Channel, Animal clinics, National parks, Museum Fisheries and aquaculture Pharmaceutical companies, animal trainers.

Medicine Related Entrance Exams

Exam	Selection Process & Test Pattern	No. of Questions	Tentative Schedule
NEET www.aipmt.nic.in **Time:** 3 Hours **Timing:** NA **Mode:** Pen and Paper	Physics Chemistry Biology **Total Questions**	45 45 90 **180**	**Form out:** Last week of Jan. **Last Date:** 1st week of March **Test Date:** 1st week of May **Negative Marking:** +4/-1 **Marks:** 720 **Forms Available:** Online
AIIMS All India Institute of Medical Sciences www.aiimsexams.org **Time:** 3.5 Hours **Timing :** NA **Mode:** Computer based	Physics Chemistry Biology GK **Total questions**	60 60 60 20 **200**	**Form out:** Mid Jan **Last Date:** Mid Feb **Test Date:** Mid May **Negative Marking:** +1/- 1/3 rd **Marks:** 200 **Forms Available:** Online
JIPMER Jawaharlal Institute of Postgraduate Medical Education & Research www.jipmer.edu.in **Time:** 2.5 Hours **Timing:** NA **Mode:** Computer based	Physics Chemistry Biology Logic & Quantitative Reasoning English Comprehension **Total Questions**	60 60 60 10 10 **200**	**Form out:** Last week of March **Last Date:** 1st week of May **Test Date:** 1st week of June **Negative Marking:** Nil **Marks:** 800 **Forms Available:** Online

- The Details given above are tentative and have been prepared as per trends of previous years.
- Please visit individual exam/institute website for exact details.

Famous National Institutes for Biologists

AIIMS

Undergraduate Courses (UG)

- MBBS
- B.Sc Nursing (post Certificate)
- B.Sc. (Hons.) Nursing
- Paramedical Courses (PM)
- B.Sc. (Hons.) Opthalmic Techniques
- B.Sc. (Hons.) Medical Technology

Postgraduate Courses (PG)

- M.D/M.S/M.D.S
- M.Ch. (5 year course)
- M.Sc. / M. Biotechnology

IARI

Undergraduate Courses (UG)

- Agricultural chemicals
- Agronomy
- Bioinformatics
- Entomology
- Horticulture
- Molecular biology and biotechnology
- Environmental sciences
- Plant pathology
- Plant genetic resources
- Nematology
- Microbiology

JIPMER

Undergraduate Courses (UG)

- M B B S
- B Sc Nursing
- B Sc Allied medical Sciences
- B.Sc. Medical Laboratory Technology
- B.Sc. Cardiac Laboratory Technology
- B.Sc. Dialysis Technology
- B.Sc. Neuro Technology
- B.Sc. Nuclear Medicine Technology
- B.Sc. Operation Theatre Technology
- B.Sc. Perfusion Technology
- B.Sc. Radiotherapy Technology
- BASLP (Bachelor in Audiology & Speech Language Pathology) (Collaboration with AIISH, Mysore. RCI approved)

Postgraduate Courses (PG)

- General Surgery
- Obstetrics & Gynaecology
- Ophthalmology
- Orthopedic Surgery
- Oto-Rhino Laryngology (E.N.T.)

IIT (Chennai)

- Biological Sciences - Dual Degree (BS & MS)

NDRI

Undergraduate Courses (UG)

- B.Tech. (Dairy Technology)

Postgraduate Courses (PG)

- Dairy Microbiology
- Dairy Chemistry
- Dairy Technology
- Dairy Engineering
- Animal Biochemistry
- Animal Genetics & Breeding
- Livestock Production & Management
- Animal Nutrition
- Animal Physiology
- Dairy Economics
- Dairy Extension Education
- Animal Biotechnology
- Agronomy (Forage production)
- Animal Reproduction, Gynecology and Obstetrics
- Food Quality and Safety Assurance

NIN (Hyderabad)

- MSc (APPLIED NUTRITION)
- POST-GRADUATE CERTIFICATE COURSE IN NUTRITION

SIDDHA

PG programme in Siddha

- Maruthuvam
- Gunapadam
- Pura Maruthuvam
- Varma Maruthuvam
- Siddhar Yoga Maruthuvam
- Kuzhandhai Maruthuvam
- Noi Nadal
- Nanju Maruthuvam

PH.D PROGRAMME

- Maruthuvam
- Gunapadam
- Sirappu Maruthuvam
- Kuzhandai Maruthuvam
- Noi Nadal
- Nanju Maruthuvam

IVRI

- MVSc
- BVSc & AH
- Animal Biochemistry
- Animal Biotechnology
- Animal Genetics and Breeding
- Animal Nutrition
- Bio-Statistics
- Epidemiology
- Livestock Economics
- Livestock Production and Management
- Livestock Products Technology
- Poultry Science
- Veterinary Bacteriology
- Veterinary Extension Education
- Veterinary Gynaecology and Obstetrics
- Veterinary Immunology
- Veterinary Medicine
- Veterinary Parasitology
- Veterinary Pathology
- Veterinary Pharmacology
- Veterinary Physiology
- Veterinary Public Health
- Veterinary Surgery & Radiology
- Veterinary Virology

National Diploma

- National Diploma in Animal Husbandry (NDAH) Division of Animal Nutrition
- National Diploma in Animal Reproduction (NDAR) Division of Animal Reproduction
- National Diploma in Veterinary Biological Products (NDBP) Division of Biological Products
- National Diploma in Equine Husbandry, Medicine and Surgery (NDEHMS)
- National Diploma in Fodder and Feed Technology(NDFFT) Division of Animal Nutrition
- National Diploma in Meet and Meat Products Technology (NDMPT) Division of Livestock Products Technology
- National Diploma in Poultry Husbandry (NDPH) CARI
- National Diploma in Preventive Veterinary Medicines (NDPVM) Div. of B & M

PhD

- Animal BiochemistryB.V.Sc.& AH with Master's degree in concerned discipline.
- Animal BiotechnologyBVSc & AH with Master's degree in Biotechnology/ Animal Biotechnology/Animal Biochemistry/ Microbiology/ Immunology/ Virology
- Animal Genetics and BreedingBVSc & AH with Master's degree in concerned discipline
- Animal NutritionB.V.Sc.& AH with Master's degree in concerned discipline.
- Livestock Production and ManagementB.V.Sc.& AH with Master's degree in concerned discipline.
- Livestock Products TechnologyB.V.Sc.& AH with Master's degree in concerned discipline.
- Poultry ScienceB.V.Sc.& AH with Master's degree in concerned discipline.
- Veterinary BacteriologyBVSc & AH with Master's degree in Vet. Bacteriology/Vet. Virology/ Vet. Microbiology/ Vet. Public Health/ Avian Diseases/ Vet. Immunology/Epidemiology/ Biotechnology
- Veterinary Extension EducationBVSc & AH with Master's degree in concerned discipline/ Vet. Medicine/ Vet. Gynaecology & Obstetrics/ Vet. Surgery/ Animal Nutrition
- Veterinary Gynaecology and ObstetricsB.V.Sc. & AH with Master's degree in concerned discipline
- Veterinary ImmunologyBVSc & AH with Master's degree in Vet. Immunology or MVSc in Vet. Microbiology/Virology/ Bacteriology/ Pathology/Biotechnology/Avian Diseases/Parasitology/ Animal Biochemistry with minor in Vet. Immunology
- Veterinary MedicineB.V.Sc.& AH with Master's degree in concerned discipline

UNIT I

Chapter 1

The Living World

Chapter Outline

"Our task must be to…embrace all living creatures and the whole of nature and its beauty."
— Albert Einstein

Learning Objectives:

- *Learns the importance of the living world and its diversity*
- *Understands the need for classification*
- *Creates an interest in systematics and understands the importance of taxonomy for classification of animals*
- *Knows the key rules of nomenclatures and their uses*

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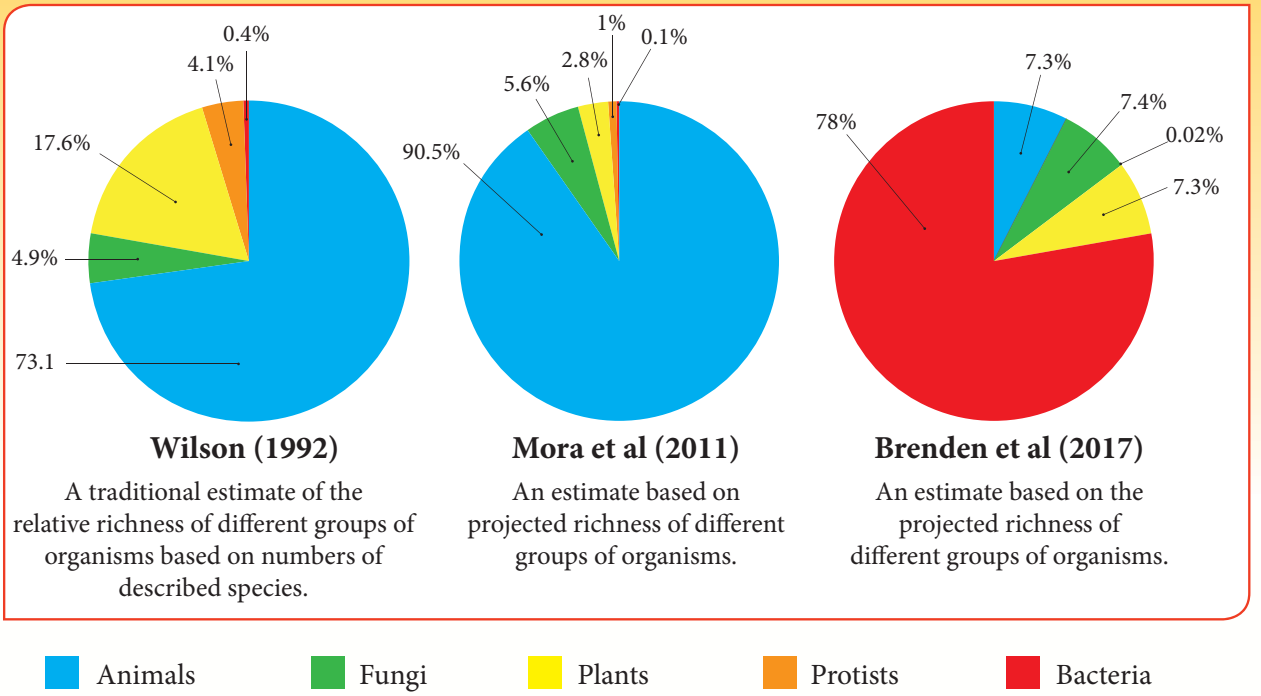
All living forms co-exist with each other. There are about 8.7 million species of animals which have been identified, named, described and classified. A study reports that 86% of all species on the land and 91% of those in the seas are yet to be discovered, described and catalogued. Though humans are placed in the top most position on the hierarchy, they have to depend on plants and animals for food. Animals are also used as source of labour, in farming, as pets, and for other economic benefits. Understanding animals and their unique characteristics, habitats, behaviour and evolutionary relationships is very important. This chapter deals with, diversity in the living world, need for classification, types of classification, taxonomical hierarchy, nomenclature and tools for studying taxonomy.

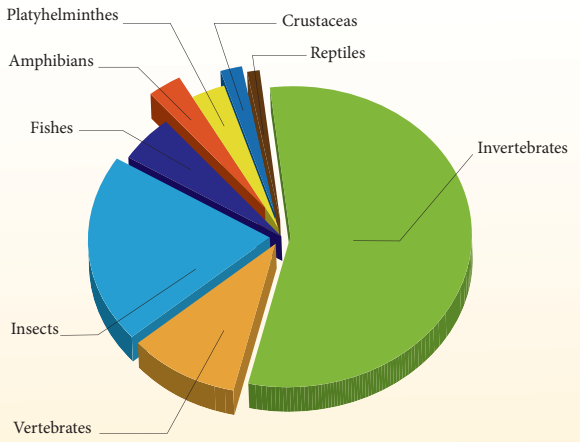
1.1 Diversity in the Living World

Earth has numerous habitats with a wide range of living organisms inhabiting them. Plants and animals are present in almost all of the places, from polar ice caps to volcanic hot springs, from shallow lagoons to the deepest oceans, from tropical rain forests to dry and parched

A new estimate of biodiversity on Earth (2017)

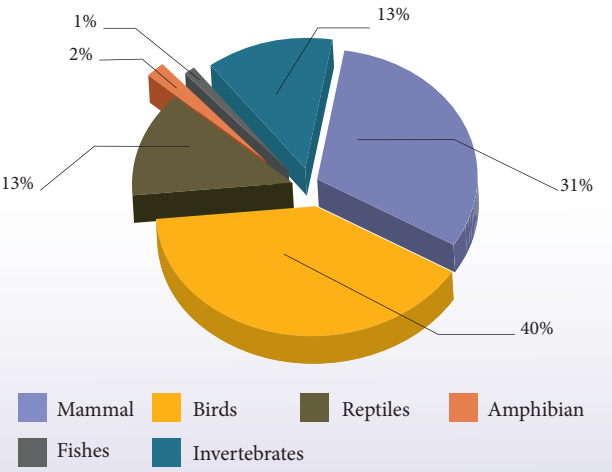


Newly Discovered Species in India (2016)



New Species Discovered in India (2016)
Of the new animal species discovered in India, 258 are invertebrates and 55 vertebrates. As many as 97 species of insects, 27 of fishes, 12 species of amphibians, 10 of Platyhelminthes, 9 of Crustacea and 6 of reptiles have been discovered and described by scientists. There are 61 species of moths and butterflies (order Lepidoptera) and 38 of beetles (Coleoptera).

Threatened Species in India



According to IUCN, 172 species of animals are considered globally threatened in India or 2.9% of the world's total number of threatened species.

These include 53 species of mammals, 69 birds, 23 reptiles and 3 amphibians, 2 fishes and 22 invertebrates.

deserts. There are a variety of species that have been adapted successfully to live in diverse ecosystems. Ecosystem is a community of living organisms (plants and animals), non-living environment (including minerals, climate, soil, water, sunlight) and their interrelationships (**A.G. Tansley, 1935**). The presence of a large number of species in a particular ecosystem is called 'biological diversity' or in short **'biodiversity'.** The term biodiversity was first introduced by **Walter Rosen (1985),** and defined by E.D. Wilson.

Difference between the Living and Non-living

Living organisms show a variety of unique characters different from non-living matter. The key characters of living organisms are, cellular organization, nutrition, respiration, metabolism, growth, response to stimuli, movement, reproduction, excretion, adaptation and homeostasis. Numerous scientists and taxonomists have made tremendous contribution and documentation in the observation and study of even minute characters in living organisms. Their keen observations have led to the classification of living organisms and the study of their interrelationships.

1.2. Need for classification

We come across many places where things are arranged in specific categories. In super markets, the shelves can have rows and columns of groceries, cosmetics, toys, stationeries, snacks and utensils. If it is not arranged in a well organized manner, customers and sales persons will waste lot of time in finding an item. In the same way, libraries also organize the books alphabetically or genres-wise into autobiographies, novels, kids stories, science fictions, etc. Likewise it is nearly impossible to study all the living organism hence it becomes necessary to device some means and methods to make this possible and this process is called classification. Classification is a process by which things are grouped in convenient categories, based on easily observable characters. The scientific term used for these categories is **taxa** (taxon–singular). Taxa indicates categories at different levels, for example Kingdom Animalia, includes multicellular animals such as reptiles, mammals, etc. Based on their characteristics, all living organisms can be classified into different taxa. This science of classification is called **taxonomy**. External and internal structures along with developmental processes and ecological information of organisms are essential, as they form basis of the taxonomical studies. Hence, characterisation, identification, nomenclature and classification are the scientific stages that are basic to taxonomy.

The basic need for classifications are:

- To identify and differentiate closely related species
- To know the variation among the species
- To understand the evolution of the species
- To create a phylogenetic tree among the different groups
- To conveniently study living organisms

1.3 Taxonomy and Systematics

Taxonomy (G. *taxis*- arrangement ; *nomos*- law) is the science of arrangement of living organisms along with classification, description, identification, and naming of organisms which includes all flora and fauna including microorganisms of the world. The word taxonomy was coined by **Augustin Pyramus de Candole (1813).** Taxonomy is a theoretical study of classification with well defined principles, rules and procedures. **Aristotle** is called the father of taxonomy (classical) and **Carolus Linnaeus** is the father of modern taxonomy.

Systematics (G. *System*/sequence)

The objectives of taxonomy and systematics are very similar; their goal is to classify organisms with stipulated rules. The main criteria of systematics is identifying, describing, naming, arranging, preserving and documenting the organisms. Apart from the above said features, evolutionary history of the species and the environmental adaptations and interrelationship between species are also being investigated in systematics.

Carolus Linnaeus is the father of modern taxonomy, which is the system of classifying and naming organisms. One of his contributions was the development of a hierarchical system of classification of nature. Today, this system includes eight taxa: domain, kingdom, phylum, class, order, family, genus, and species.

History of Classification

Early classification of organisms were based on only two criteria, beneficial or harmful animals. An ancient classification system recognized 5 animal groups - domestic, wild, creeping, flying and sea animals. Initially the classification was based on organism's fundamental characteristics such as the habitat and morphology only.

Aristotle (384 to 322 BC), was the first to classify all animals in his **History of Animals** (*Historia Animalium* in Latin). He attempted a basic classification of all living organisms into Plants and Animals. Animals were classified based on locomotion; walking (terrestrial), flying (aerial) and swimming (aquatic). Based on the presence or absence of red blood he classified the animals into two as *Enaima* with blood and those without blood as *Anaima*.

Aristotle's classification system had limitations and many organisms were not fitting into his classification. For example, the tadpoles of frogs are born in water and have gills but when they metamorphosed into adult frogs they have lungs and can live both in water and on land. How to classify frogs and where to place them? Aristotle classified organisms based on locomotion, hence, birds, bats, and flying insects were grouped together just by observing one single characteristic feature, the flying ability. On the contrary to the above said

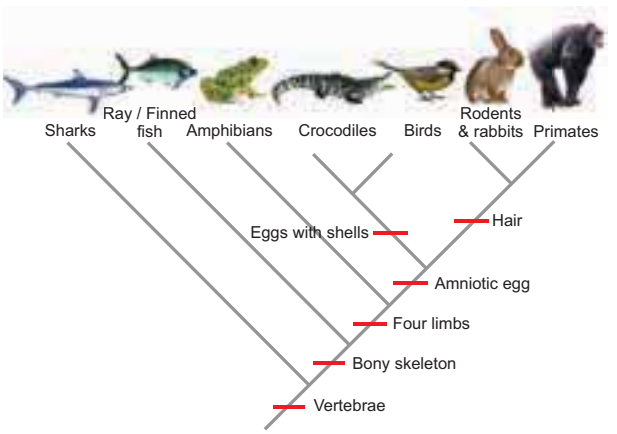
example, the ostrich, emu and penguin are all birds but cannot fly. So Aristotle would not have classified them as birds. In spite of these limitations Aristotle's classification system was followed for more than 2000 years upto 1700.

After Aristotle, his student **Theophrastus** (372-287 BC) continued his research on the classification of plants, and he was known as the "Father of Botany." There was a huge gap till 16th century, then the English naturalist **John Ray** (1627–1705) wrote several important works through his life. His most important contribution was the establishment of species as the ultimate unit of taxonomy. In 1682 he published the *Methodus Plantarum Nova*, which contained about **18,000** plant species, a result of a relatively narrow species concept. His complicated classification was based on many combined characters, as opposed to earlier taxonomists. John Ray also aimed at publishing a complete system of nature, which included works on mammals, reptiles, birds, fishes and insects. The Swedish biologist **Carolus Linnaeus (1707 - 1788)** father of modern taxonomy and founder of modern systematics developed a scientific system of taxonomy and binomial nomenclature, which is still (with modifications) in use.

Aristotle to Linnaeus employed easily observable single to few traits for classification of organisms. With increased knowledge of the several biological domains, many characters were considered for classifying organisms. This represented the phase of classical taxonomy which was based on overall similarities or affinities derived from morphology, anatomy and embryology of organisms. A modification of this system is the numerical taxonomy, which evolved in the 1950s. This system evaluates the resemblances and differences through statistical methods followed by computer analyses to establish the numerical degree of relationship among individuals. Later on biologists initiated studies on the evolutionary and genetic relationships among organisms, which led to the emerge of **phylogenetic classification or cladistics.** It is an evolutionary classification based on how a common ancestry was shared. Cladistic classification summarizes the genetic differences between all species in the 'phylogenetic tree'. Ernst Haeckal introduced the method of representing evolutionary relationships with the help of a tree diagram known as cladogram.

This system of classification takes into account ancestral characters (traits of basic body design which would be in the entire group) and derived characters (traits whose structure and functions differs from those of ancestral characters). One or more derived characters which appeared during evolution resulted in the formation of new subspecies. In a cladogram each evolutionary step produces a branching and all the

Figure 1.1. Example of a Cladogram



members of the branch would possess the derived character which will not be seen in organisms below the particular branch point. Arranging organisms on the basis of their similar or derived characters which differ from the ancestral characters produced a phylogenetic tree or cladogram (Figure 1.1).

Depending on the system of classification, organisms were classified into two or three kingdoms. Later into four, five, six and now into seven kingdoms. R.H.Whittaker (1969) proposed the **Five kingdom Classification**, the Kingdoms defined by him were Monera, Protista, Fungi, Plantae, and Animalia based on the cell structure, mode of nutrition, mode of reproduction and phylogenetic relationships. Table 1. gives a comparative account of different characteristics of the five kingdoms.

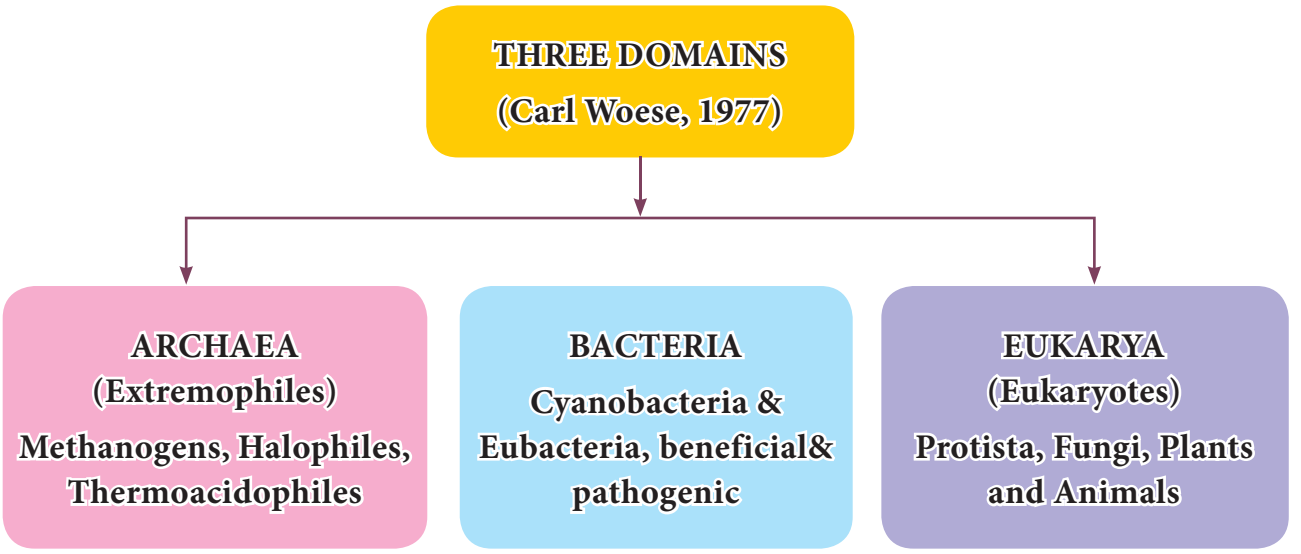
Classification has come a long way and now takes into an account even molecular level DNA and RNA identification. The advancement in molecular techniques and biochemical assays has led to a new classification - The "Three Domain" classification.

1.4. Three Domains of life

Three domain classification was proposed by **Carl Woese** (1977) and his co-workers. They classified organisms based on the difference in 16S rRNA genes. The three domain system adds the taxon 'domain' higher than the kingdom. This system emphasizes the separation of Prokaryotes into two domains, Bacteria and Arachaea, and all the eukaryotes are placed into the domain Eukarya. Archaea appears to have more in common with the Eukarya than the Bacteria. Archaea differ from bacteria in cell wall composition and differs from bacteria and eukaryotes in membrane composition and rRNA types.

DO YOU KNOW?

Thermus aquatics is a bacterium which can tolerate high temperatures. The first DNA polymerase enzyme was isolated from *T. aquaticus* it is used in **PCR** (Polymerase Chain Reaction) for DNA amplification.



1. Domain Archaea

This domain includes single celled organisms, the prokaryotes which have the ability to grow in extreme conditions like volcano vents, hot springs and polar ice caps, hence are also called **extremophiles.** They are capable of synthesizing their food without sunlight and oxygen by utilizing hydrogen sulphide and other chemicals from the volcanic vents. Some of the them produced methane (methanogens), few live in salty environments (Halophiles) and are thermoacidophiles which thrive in acidic environments and at high temperatures.

2. Domain Bacteria

Bacteria are prokaryotic, their cells have no definite nucleus and DNA exists as a circular chromosomes and do not have histones associated with it. They do not possess membrane bound organelles except for ribosome (70S type). Their cell wall contains peptidoglycans. Many are decomposers, some are photo-synthesizers and few cause diseases. There are beneficial **probiotic** bacteria and harmful **pathogenic** bacteria which are diversely populated. Cyanobacteria are photosynthetic blue green algae which produce oxygen. These had played a key role in the changes of atmospheric oxygen levels from anaerobic to aerobic during the early geologic periods.

Curd is one of the best sources of probiotics, which are friendly bacteria that can improve our health. e.g. *Lactobacillus sp.*

3. Domain Eukarya (Eukaryotes)

Eukaryotes are animals which have true nucleus and membrane bound organelles. DNA in the nucleus is arranged as a linear chromosome with histone proteins, ribsosomes of 80S type in the cytosol and 70S type in the chloroplast and mitochondria. Animals in this domain are classified under kingdoms, namely, Protista, Fungi, Plantae and Animalia.

In 1987, **Cavalier-Smith** revised the six kingdom system to **Seven Kingdom system.** The concept of super kingdom was introduced and revised to seven kingdom classification. The classification is divided

FIVE KINGDOM CLASSIFICATION

Salient features	KINDS OF KINGDOM				
	Monera	Protista	Fungi	Plantae	Animalia
Cell type	Prokaryotic	Eukaryotic	Eukaryotic	Eukaryotic	Eukaryotic
Cell wall	Non-cellular	Present in some	Present	Present	Absent
Body organisation	Cellular	Cellular	Multicelluar Tissue	Tissue Organ	Tissue Organ Organ system
Mode of nutrition	Autotrophic Heterotrophic	Autotrophic Heterotrophic	Heterotrophic	Autotrophic	Heterotrophic

Table 1. Five Kingdom Classification

into two Super Kingdoms (Prokaryota and Eukaryota) and seven kingdoms, two Prokaryotic Kingdoms (Eubacteria and Archaebacteria) and five Eukaryotic Kingdoms (Protozoa, Chromista, Fungi, Plantae and Animalia).

The Three-Domain System

Bacteria | Archaea | Eukarya

The traditional Five – Kingdom system

Monera | Protista | Fungi | Plantae | Animalia

The Six –Kingdom system

Bacteria | Archaea | Protista | Fungi | Plantae | Animalia

The Seven – Kingdom system

Eubacteria | Archae-bacteria | Protozoa | Chromista | Fungi | Plantae | Animalia

1.5. Taxonomic hierarchy

In biological classification, the taxonomical hierarchy includes seven major categories namely kingdom, phylum, class, order, family, genus and species and other intermediate categories such as subkingdom, grade, division, subdivision, subphylum, superclass, subclass, superorder, suborder, superfamily, subfamily and subspecies.

Figure 1.2 Sterile offsprings

Species

Species is the basic unit of classification in the taxonomic hierarchial system. It is a group of animals having similar morphological features (traits) and is reproductively isolated to produce fertile offspring. There are some exceptional animals which can produce **sterile offspring** because of mating with closely related species (Figure 1.2).

Crosses between

Male horse and Female Donkey results in Hinny (Sterile).

Male Donkey and Female Horse results in Mule (Sterile)

Male Lion and Female Tiger results in Liger

Male Tiger and Female Lion results in Tigon

Genus: It is a group of closely related species which have evolved from a common ancestor. In some genus there is only one species which is called as **monotypic genus** (e.g. Red panda is the only species in the genus *Ailurus* : *Ailurus fulgens*) (Figure 1.3). If there are more than one species in the genus it is known as **polytypic genus,** for example 'cats' come under the Genus *Felis*, which has a number of closely related species, *Felis domestica* (domestic cat), *Felis margarita* (jungle cat). *Felis silvestris* (wild cat)

Figure 1.3 Red Panda – *Ailurus fulgens*

Systematics of Human being

KINGDOM
Animalia

PHYLUM
Chordata – Animals with a notochord or vertebral column (Back bone)

CLASS
Mammalia – Body covered with hair or fur. Mammary glands are present

ORDER
Primata – Mammals with forward looking eyes and grasping fingers

FAMILY
Hominidae – Primates with relatively flat faces and binocular vision

GENUS
Homo – Hominids with large brain and upright posture

SPECIES
Homo sapiens – Bipedal and higher intelligence

Family: It is a taxonomic category which includes a group of related genera with less similarity as compared to genus and species. For example, the family Felidae includes the genus *Felis* (cats) and the genus *Panthera* (lions, tigers, leopards).

Order: This category includes an assemblage of one or more related families which show few common features. One or more similar families are grouped together to form an order. For example, family *Canidae* and *Felidae* are placed in the order Carnivora.

Class: This category includes one or more related orders with some common characters. For example order Primata comprising monkeys, apes and man is placed in the Class Mammalia, along with the order Carnivora which includes dogs and cats.

DO YOU KNOW?

Recently Discovered species in South India

Scientists have discovered a new and unusual species of frog in the Western Ghats in India in August 2017. The frog has shiny, purple skin, a light blue ring around its eyes, and a pointy pig-nose. It is named as Bhupathy's purple frog (*Nasikabatrachus bhupathi*) to honour Dr.Subramaniam Bhupathy, herpetologist who lost his life in the Western Ghats in 2014.

DO YOU KNOW?

Biological nomenclature derives from the binomial (or binominal) nomenclature that was originally codified in the works of Linnaeus, *Species Plantarum* (1753) and *Systema Naturae*, 10th Edition (1758). These publications are the starting points for the modern biological nomenclature in most groups of plants and animals.

Phylum: The group of classes with similar distinctive characteristics constitute a phylum. The classes Pisces, Amphibia, Reptilia, Aves and Mammalia constitute the next higher category, phylum Chordata. These classes share some common features like presence of a notochord and a dorsal tubular nerve cord hence included in the phylum Chordata.

685SKG

Kingdom: All living animals belonging to various phyla are included in the Kingdom Animalia and it is the top most of the taxonomic hierarchy.

DO YOU KNOW?

In July, 2017, a 9 years old boy discovered a new Freshwater species of Jellyfish in the Kodaikanal lake, Tamilnadu.

1.6. Nomenclature

Giza, Inimene, Emberi, Manna,
Doanna, Umano .....

In all probability these words must be new to you…but they all mean "Human"

in different foreign languages! There are presently more than 6000 languages in the world and an animal can be named in more than 6000 ways! Unfortunately it is impossible for anyone to have a good functioning knowledge of most languages and hence there arises a need for a universally accepted scientific naming system for all organisms. The process of assigning scientific names to animals or taxonomic group is called nomenclature. For example, worldwide, the scientific name *Homo sapiens* denotes *human*. Classification and grouping were done to facilitate a deeper understanding of the unique characteristics of each organism and its interrelationship among closely related species. It plays a vital role in the arrangement of known species based on their similarities and dissimilarities. Numerous characters such as morphology, genetic information, habitat, feeding pattern, adaptations, evolution, etc., are examined before an organism is named.

One of the primary responsibilities of systematic biology is the development of biological nomenclature and classification. Nomenclature is not an end to systematics and taxonomy but it is necessary in organizing information about biodiversity. Nomenclature, functions to provide names for all taxa at all levels in the hierarchy of life. Naming of the organisms is done based on the guidelines of the International Code of Zoological Nomenclature (ICZN). The scientific name ensures that each organism has only one name.

DO YOU KNOW?

A newly discovered Himalayan forest thrush bird was named after the birdman of India, Ornithologist Dr. Salim Ali. The name of the bird is "*Zoothera salimalii*". A fruit bat is also named after him "*Latidens salimalii*"

Binomial Nomenclature (L. *Bi*-two; *Nomen*-Name)

Biologists follow universally accepted principles to provide scientific names to known organisms. Each name has two components, a generic name and a specific epithet. This system of naming the organism is called **Binomial Nomenclature** which was popularised by Carolus Linnaeus and practised by biologists all over the world. Example, the National Bird (Indian Peafowl) – *Pavo cristatus*, the National Animal tiger as *Panthera* tigris, and the Tamil Nadu State bird is the common Emerald dove *Chalcophaps indica*.

Trinominal Nomenclature (*Tri* – three)

This naming system was proposed by Huxley and Stricklandt, Trinomen means, three names: generic name, species name and sub-species name. When members of any species which have large variations then trinomial system is used. On the basis of dissimilarities, this species gets classified into subspecies. It is the

If you find an animal with four legs, with two eyes, paired ear pinna, covered with fur, possessing mammary gland , which class will you position it? How will you give a binomial name, if you are the first person to discover and report that animal.

extension of binominal nomenclature system which has an addition of subspecies. All the three names are set in italics and only the generic name is capitalized, if handwritten then it should be underlined separately E.g.*Corvus splendens splendens* (Indian house crow)

Tautonymy: The practice of naming the animals in which the generic name and species name are the same, is called Tautonymy. e.g. *Naja naja* (The Indian Cobra).

What may be the reasons for the extinction of Dinosaurs? If you know the reasons for their extinction, why Sparrows are listed as endangered species?

Rules of Nomenclature

- The scientific name should be italicized in printed form and if handwritten, it should be underlined separately.
- The generic name's (*Genus*) first alphabet should be in uppercase.
- The specific name (*species*) should be in lowercase.
- The scientific names of any two organisms are not similar.
- The name or abbreviated name of the scientist who first publishes the scientific name may be written after the species name along with the year of publication. For example Lion-*Felis leo* Linn., 1758 or *Felis leo* L., 1758.
- If the species name is framed after any person's name the name of the species shall end with i, ii or ae.

For example, a new species of a ground-dwelling lizard (Cyrtodactylus) has been discovered and named after Scientist Varad Giri, *Cyrtodactylus varadgirii*.

1.7. Concept of species

Species is the basic unit of classification. The term species was coined by John Ray, and in his book "*Historia Generalis Plantarum*" (3 volumes) in 1693 described species as a group of morphologically similar organisms arising from a common ancestor. Carolus Linnaeus in his book "*Systema naturae*" considered species as the basic unit of classification. Species can be defined as a group of organisms that have similar morphology and physiology and can interbreed to produce fertile offsprings. In 1859 Charles Darwin in his book **Origin of species** explains the evolutionary connection of species by the process of natural selection.

68ENM4

1.8 Tools for study of taxonomy

Tools and taxonomical aids may be different for the study of plants and animals. Herbarium and Botanical garden may be used as tools for the study of plant taxonomy. In the case of animal studies, the classical tools are Museum, Taxonomical Keys and Zoological and Marine parks.

Arignar Anna Zoological Park, also known as the Vandalur Zoo is in the south western part of Chennai, Tamil Nadu, spreads over an area of 1500 acres, is one of the largest zoological parks in India. The zoo houses 2,553 species of both flora and fauna.

The important components of the taxonomical tools are field visits, survey, identification, classification, preservation and documentation. Many tools are being used for taxonomical studies, amongst them some of the important tools are discussed below:

The classical taxonomical tools

Taxonomical Keys: Keys are based on comparative analysis of the similarities and dissimilarities of organisms. There are separate keys for different taxonomic categories.

Museum: Biological museums have collection of preserved plants and animals for study and ready reference. Specimens of both extinct and living organisms can be studied.

Zoological parks: These are places where wild animals are kept in protected environments under human care. It enables us to study their food habits and behaviour.

Marine parks: Marine organisms are maintained in protected enviroments.

Printed taxonomical tools consist of identification cards, description, field guides and manuals.

Molecular taxonomical tools

Technological advancement has helped to evolve molecular taxonomical tools from classical tools to molecular tools. The accuracy and authenticity is more significant in the molecular tools. The following methods are being used for taxonomical classification.

Molecular techniques and approaches such as **DNA barcoding** (short genetic marker in an organism's **DNA** to identify it as belonging to a particular species), **DNA hybridization** (measures the degree of genetic similarity between pools of DNA sequences), **DNA fingerprinting** (to identify an individual from a sample of DNA by looking at unique patterns in their DNA), Restriction Fragment Length Polymorphisms (RFLP) analysis (difference in homologous DNA sequences that can be detected by the presence of fragments of different lengths after digestion of the DNA samples), and Polymerase Chain Reaction (PCR) sequencing (to amplify a specific gene, or portion of gene,) are used as taxonomical tools.

Automated species identification tools

It consists of Cyber tools. For example: DAISY, ALIS, ABIS, SPIDA, Draw wing, etc.

ALIS ➜ Automated Leafhopper Identification System.

DAISY ➜ Digital Automated Identification System.

ABIS ➜ Automatic Bee Identification System.

SPIDA ➜ Species Identified Automatically (spiders, wasp and bee wing characters).

Draw wing ➜ Honey bee wing identification.

Neo taxonomical tools – This is based on Electron Microscopy images to study the molecular structures of cell organelles.

Ethology of taxonomical tools – Based on the behaviour of the organisms it can be classified. For example sound of birds, bioluminescence, etc.

e-Taxonomic resources – INOTAXA is an electronic resource for digital images and description about the species which was developed by Natural History Museum, London. **INOTAXA** means **In**tegrated **O**pen **TAX**onomic **A**ccess.

Activity

The main objective of this activity is to check the students understanding about animals and its characteristics before learning the lesson. Observe the picture given below, identify the animals and classify them according to you own understanding; write one character about each class of animals.

Take the students to the school ground and ask them to observe and identify few invertebrates (insects, earthworm, spiders etc). Ask the students to write few characteristics of each animal which they have observed.

Sl.No	Name of the Animal	Known Character	Class	Habitat
1				
2				
3				
4				

ICT Corner

Deep Tree

Let's do this activity to know the position of a particular species in the **Evolution path**.

Step – 1

Type the URL in the browser. Click 'Play Game' button then use your personal or school id to login. Otherwise use Guest Pass to enter. Then click the DEEP TREE icon that is given below The Evolution Lab to start the activity.

Step – 2

Input the common name of any animal in the SEARCH tab given at the bottom of the activity window, select the appropriate Zoological name from the list appeared.

Step – 3

The Classification and the place of the species in the animal Kingdom can be viewed by clicking the Icon placed next to the search tab.

Step – 4

Two different species can be compared by clicking on the RELATE button given at the bottom of the activity window. The relation between those species can be learnt by clicking the DNA icon appeared.

Step 1

Step 2

Step 3

Step 4

DEEP TREE url
http://www.pbs.org/wgbh/nova/labs/lab/evolution/

B167_STD_11_ZOOLOGY_EM

* Pictures are indicative only

Summary

Earth has numerous habitats with a wide range of living organisms inhabiting it. Living organisms show a variety of unique characters different from non-living matter. Classification is the process by which anything is grouped in a convenient category based on some easily observable characters.

Taxonomy is the science of arrangement of living organisms. R. H. Whittaker proposed the five kingdom classification. Three domain classification was proposed by Carl Woese and his co-workers.

The taxonomical hierarchy includes seven categories namely kingdom, phylum, class, order, family, genus and species. The process of assigning scientific names to animal or taxonomic group is called nomenclature. Each scientific name has two components, generic name and a specific epithet. The important component of the taxonomical tools are field visits, survey, identification, classification, preservation and documentation. Molecular taxonomical tools are more accurate, authentic and significant for taxonimical classification.

Glossary

Cladogram – A branching diagram showing the relationship between a number of species.

Phylogeny – Relationships among various biological species based upon similarities and differences in their physical or genetic characteristics.

Phylogenetic tree – A phylogenetic tree or evolutionary tree is a branching diagram or "tree" showing the inferred evolutionary relationships upon similarities and differences in their physical or genetic characteristics.

Shared character – A shared character is one that two lineages have in common

Derived character – Derived character is one that evolved in the lineage leading up to a clade.

Threatened species – Species which are vulnerable to endangerment in the near future.

Evaluation

1. A living organism is differentiated from non-living structure based on
   a. Reproduction
   b. Growth
   c. Metabolism
   d. Movement

2. A group of organisms having similar traits of a rank is
   a. Species
   b. Taxon
   c. Genus
   d. Family

3. Every unit of classification regardless of its rank is
   a. Taxon
   b. Variety
   c. Species
   d. Strain
4. Which of the following is not present in same rank?
   a. Primata
   b. Orthoptera
   c. Diptera
   d. Insecta
5. What taxonomic aid gives comprehensive information about a taxon?
   a. Taxonomic Key
   b. Herbarium
   c. Flora
   d. Monograph
6. Who coined the term biodiversity?
   a. Walter Rosen
   b. AG Tansley
   c. Aristotle
   d. AP de Candole
7. Cladogram considers the following characters
   a. Physiological and Biochemical
   b. Evolutionary and Phylogenetic
   c. Taxonimic and systematic
   d. None of the above
8. Molecular taxonomic tool consists of
   a. DNA and RNA
   b. Mitochondria and Endocplamic reticulum
   c. Cell wall and Membrane proteins
   d. All the above
9. Differentiate between probiotics and pathogenic bacteria
10. Why mule is sterile in nature?
11. List any five salient features of the family *Felidae*
12. What is the role of Charles Darwin in relation to concept of species?
13. Why elephants and other wild animals are entering into human living area?
14. What is the difference between a Zoo and wild life sanctuary?
15. Can we use recent molecular tools to identify and classify organisms?
16. Explain the role of Latin and Greek names in Biology.

References

1. Peter H. Raven, George B. Johnson, Susan R. Singer, Jonathan B. Losos (2004) Biology 7th Edition Published by McGraw-Hill Science.
2. Janet L. Hopson and John Postlethwait (2006) Modern Biology Published by Holt Rinehart & Winston Harcourt Education Company.
3. Peter H. Raven, George B. Johnson, Kenneth A. Mason, Jonathan B. Losos, Susan R. Singer (2013) Biology 9th Edition. Published by McGraw-Hill Science.

UNIT I

Chapter 2

Kingdom Animalia

Chapter Outline

March 20th is celebrated as World Sparrow day to conserve this endangered species, House sparrow (*Passer domesticus*)

Learning Objectives:

- *Justifies the need for classification.*
- *Understands the salient features of the animal phyla.*

68NJNR

Kingdom Animalia comprises millions of animal species and studying them without a basic classification may lead to confusion. In addition to this, there are several new species of animals being constantly discovered. Classification is very essential for identification, naming and assigning a systematic position to the newly discovered species. Animal Kingdom is classified mainly based on the closely resembling characteristic features. Kingdom Animalia is characterised of eukaryotic, multicellular, heterotrophic organisms. They include about 35 phyla of which 11 are considered as major phyla. Almost 99 percent of animals are invertebrates or animals without backbone. The remaining represents vertebrates or animals with backbone. On the basis of the presence or absence of notochord (vertebral column), animals are also categorised into two major groups and they are non chordates and chordates.

2.1 Basis of classification

Multicellular organisms are structurally and functionally different but yet they possess certain common fundamental features such as the arrangement of cell layers, the levels of organisation, nature of coelom, the presence or absence of segmentation, notochord and the organisation of the organ system.

2.1.1. Levels of organisation

All members of Kingdom Animalia are metazoans (multicellular animals) and exhibit different patterns of cellular organisation. The cells of the metazoans

are not capable of independent existence and exhibit division of labour. Among the metazoans, cells may be functionally isolated or similar kinds of cells may be grouped together to form tissues, organ and organ systems.

Cellular level of organisation

This basic level of organisation is seen in sponges. The cells in the sponges are arranged as loose aggregates and do not form tissues, i.e. they exhibit cellular level of organisation. There is division of labour among the cells and different types of cells are functionally isolated. In sponges, the outer layer is formed of pinacocytes (plate-like cells that maintain the size and structure of the sponge) and the inner layer is formed of choanocytes. These are flagellated collar cells that create and maintain water flow through the sponge thus facilitating respiratory and digestive functions.

Animals such as sponges lack nervous tissue and muscle tissue, what does this tell you about sponges?

Tissue level of organisation

In some animals, cells that perform similar functions are aggregated to form tissues. The cells of a tissue integrate in a highly coordinated fashion to perform a common function, due to the presence of nerve cells and sensory cells. This tissue level of organisation is exhibited in diploblastic animals like cnidarians. The formation of tissues is the first step towards evolution of body plan in animals. (*Hydra* - Coelenterata).

Organ level of organisation

Different kinds of tissues aggregate to form an organ to perform a specific function. Organ level of organisation is a further advancement over the tissue level of organisation and appears for the first time in the Phylum Platyhelminthes and seen in other higher phyla.

Organ system level of organisation

The most efficient and highest level of organisation among the animals is exhibited by flatworms, nematodes, annelids, arthropods, molluscs, echinoderms and chordates. The evolution of mesoderm in these animals has led to their structural complexity. The tissues are organised to form organs and organ systems. Each system is associated with a specific function and show organ system level of organisation. Highly specialized nerve and sensory cells coordinate and integrate the functions of the organ systems, which can be very primitive and simple or complex depending on the individual animal. For example, the digestive system of Platyhelminthes has only a single opening to the exterior which serves as both mouth and anus, and hence called an incomplete digestive system. From Aschelminthes to Chordates, all animals have a complete digestive system with two openings, the mouth and the anus.

Similarly, the circulatory system is of two types, the **open type**: in which the blood remains filled in tissue spaces due to the absence of blood capillaries. (arthropods, molluscs, echinoderms, and urochordates) and the **closed type:** in which the blood is circulated through blood vessels of varying diameters (arteries, veins, and capillaries) as in annelids, cephalochordates and vertebrates.

2.1.2. Diploblastic and Triploblastic organisation

During embryonic development, the tissues and organs of animals originate from two or three embryonic germ layers. On the basis of the origin and development, animals are classified into two categories: Diploblastic and Triploblastic.

Animals in which the cells are arranged in two embryonic layers (Figure 2.1), the external ectoderm, and internal endoderm are called **diploblastic animals**. In these animals the ectoderm gives rise to the epidermis (the outer layer of the body wall) and endoderm gives rise to gastrodermis (tissue lining the gut cavity). An undifferentiated layer present between the ectoderm and endoderm is the mesoglea. (Corals, Jellyfish, Sea anemone)

Animals in which the developing embryo has three germinal layers are called **triploblastic** animals and consists of outer ectoderm (skin, hair, neuron, nail, teeth, etc), inner endoderm (gut, lung, liver) and middle mesoderm (muscle, bone, heart). Most of the triploblastic animals show organ system level of organisation (Flat worms to Chordates).

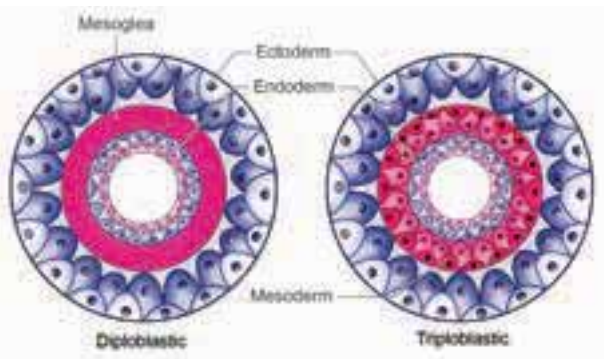


Figure 2.1 Germinal layers

2.1.3. Patterns of symmetry

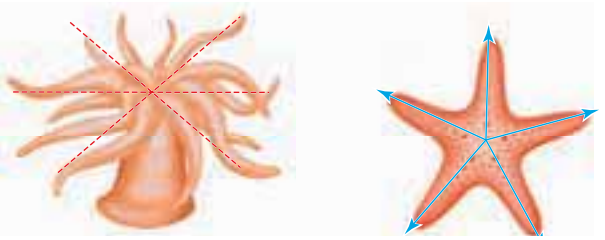
Symmetry is the body arrangement in which parts that lie on opposite side of an axis are identical. An animal's body plan results from the animal's pattern of development. The simplest body plan is seen in sponges (Figure 2.2). They do not display symmetry and are **asymmetryical**. Such animals lack a definite body plan or are irregular shaped and any plane passing through the centre of the body does not divide them into two equal halves (Sponges). An asymmetrical body plan is also seen in adult gastropods (snails).

Figure 2.2. Asymmetry in sponges

Symmetrical animals have paired body parts that are arranged on either side of a plane passing through the central axis. When any plane passing through the central axis of the body divides an organism into two identical parts, it is called **radial symmetry**. Such radially symmetrical animals have a top and bottom side but no dorsal (back) and ventral (abdomen) side, no right and left side. They have a body plan in which the body parts are organised in a circle around an axis. It is the principal symmetry in diploblastic animals. Cnidarians such as sea anemone and corals (Figure 2.3) are radially symmetrical. However, triploblastic animals like echinoderms (e.g., starfish) have five planes of symmetry and show **Pentamerous radial symmetry**.

Animals which possess two pairs of symmetrical sides are said to be **biradially symmetrical** (Figure 2.4). Biradial symmetry is a combination of radial and bilateral symmetry as seen in ctenophores. There are only two planes of symmetry, one through the longitudinal and sagittal axis and the other through the longitudinal and transverse axis. (e.g., Comb jellyfish – *Pleurobrachia*)

Animals which have two similar halves on either side of the central plane show **bilateral symmetry** (Figure 2.5). It is an advantageous type of symmetry in triploblastic animals, which helps in seeking food, locating mates and escaping from predators more efficiently. Animals that have dorsal and ventral sides, anterior and posterior ends, right and left sides are bilaterally symmetrical and exhibit cephalisation, in which the sensory and brain structures are concentrated at the anterior end of the animal (Figure 2.6).



Radial symmetry in sea anemone *Pentamerous radial symmetry in starfish*

Figure. 2. 3 Radial and Pentamerous radial symmetry

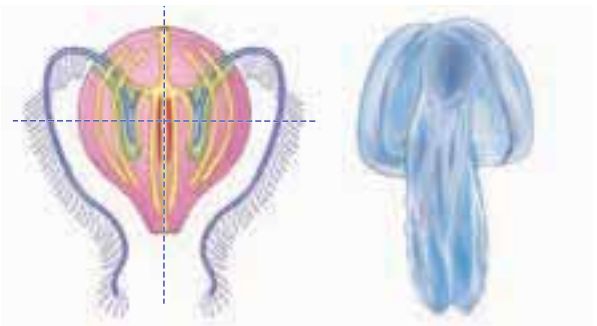


Figure 2.4 Biradial symmetry in comb jelly

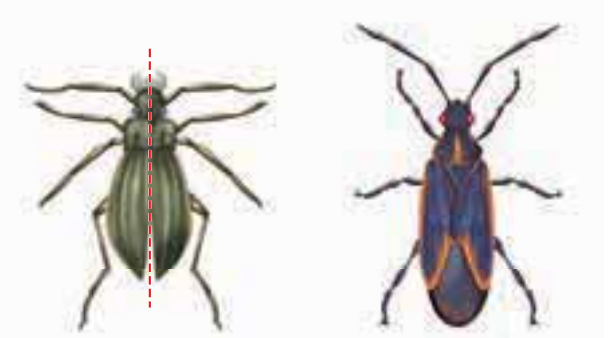


Figure 2.5 Bilateral symmetry in Insects

2.1.4. Coelom

The presence of body cavity or coelom is important in classifying animals. Most animals possess a body cavity between the body wall and the alimentary canal, and is lined with mesoderm.

Animals which do not possess a body cavity are called acoelomates. Since there is no body cavity in these animals their body is solid without a perivisceral cavity, this restricts the free movement of internal organs. (e.g., Flatworms)

In some animals, the body cavity is not fully lined by the mesodermal epithelium, but the mesoderm is formed as scattered pouches between the ectoderm and endoderm. Such a body cavity is called a **pseudocoel** and is filled with pseudocoelomic fluid. Animals that possess a pseudocoel are called pseudocoelomates e.g., Round worms. The pseudocoelomic fluid in the pseudocoelom acts as a hydrostatic skeleton and allows free movement of the visceral organs and for circulation of nutrients.

Eucoelom or true coelom is a fluid-filled cavity that develops within the mesoderm and is lined by mesodermal

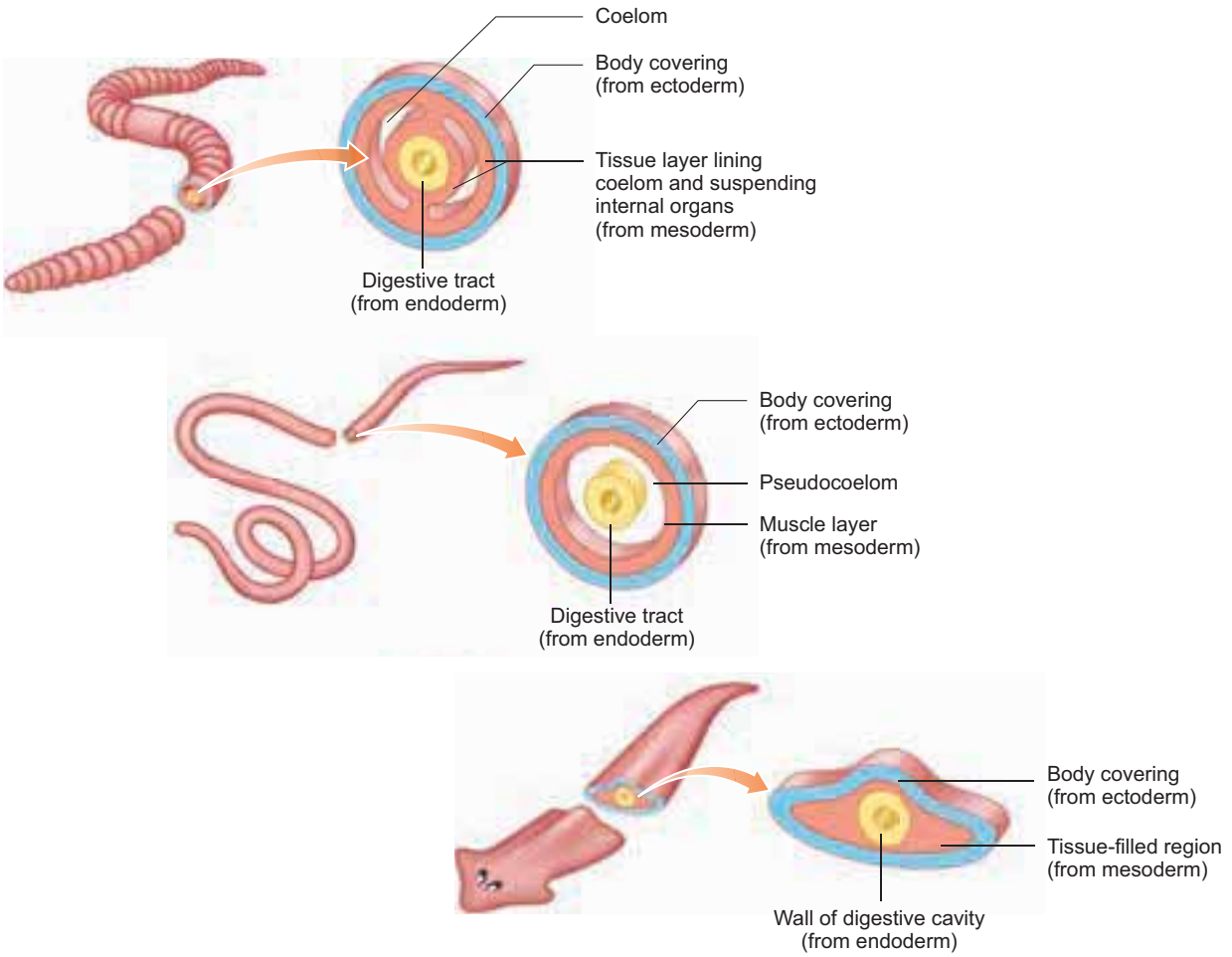


Figure 2.6 Cross section of coelom in animals

epithelium called peritoneum. Such animals with a true body cavity are called coelomates or eucoelomates. Based on the mode of formation of coelom, the eucoelomates are classified into two types, **Schizocoelomates** – in these animals the body cavity is formed by splitting of mesoderm. (e.g., annelids, arthropods, molluscs). In **Enterocoelomate animals** the body cavity is formed from the mesodermal pouches of archenteron. (e.g., Echinoderms, hemichordates and chordates) (Figure 2.7).

What is the advantage of true coloem over a pseudocoelom?

2.1.5. Segmentation and Notochord

In some animals, the body is externally and internally divided into a series of repeated units called segments with a serial repetition of some organs (Metamerism). The simplest form of segmentation is found in Annelids in which each unit of the body is very similar to the next one. But in arthropods (cockroach), the segments may look different and has different functions.

Animals which possess notochord at any stage of their development are called chordates. Notochord is a mesodermally derived rod like structure formed on the dorsal side during embryonic development in some animals. Based on the presence

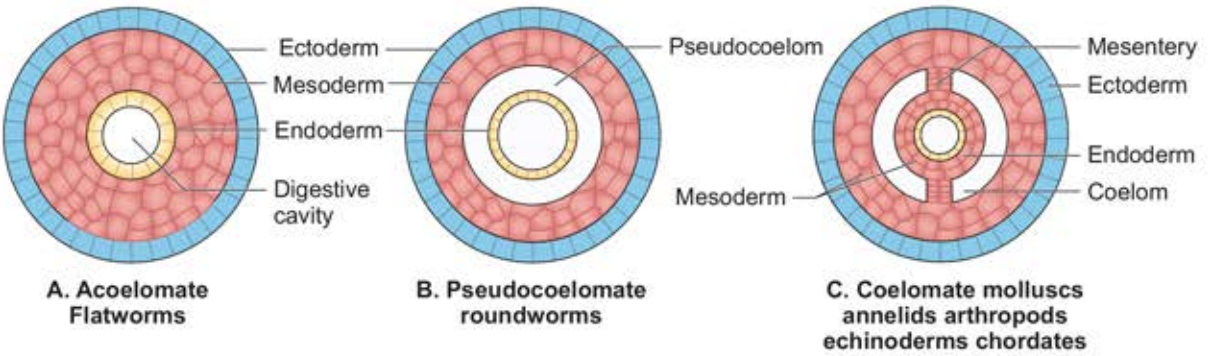


Figure 2.7 Diagrammatic representation of Coelom in Animals

or absence of notochord, animals are classified as chordates (Cephalochordats, Urochordates, Pisces to Mammalia) and nonchordates (Porifera to Hemichordata).

2.2 Classification of Kingdom Animalia

Animal kingdom is divided into two sub-kingdoms, the Parazoa and Eumetazoa based on their organisation.

1. **Parazoa**: These include the multicellular sponges and their cells are loosely aggregated and do not form tissues or organs.

2. **Eumetazoa**: These include multicellular animals with well defined tissues, which are organised as organs and organ systems. Eumetazoans includes two taxonomic levels called grades. They include **Radiata** and **Bilateria**.

Grade: 1 Radiata

Among the eumetazoa, a few animals have an organisation of two layers of cells, the outer ectoderm and inner endoderm, separated by a jelly like mesoglea. They are radially symmetrical and are diploblastic.

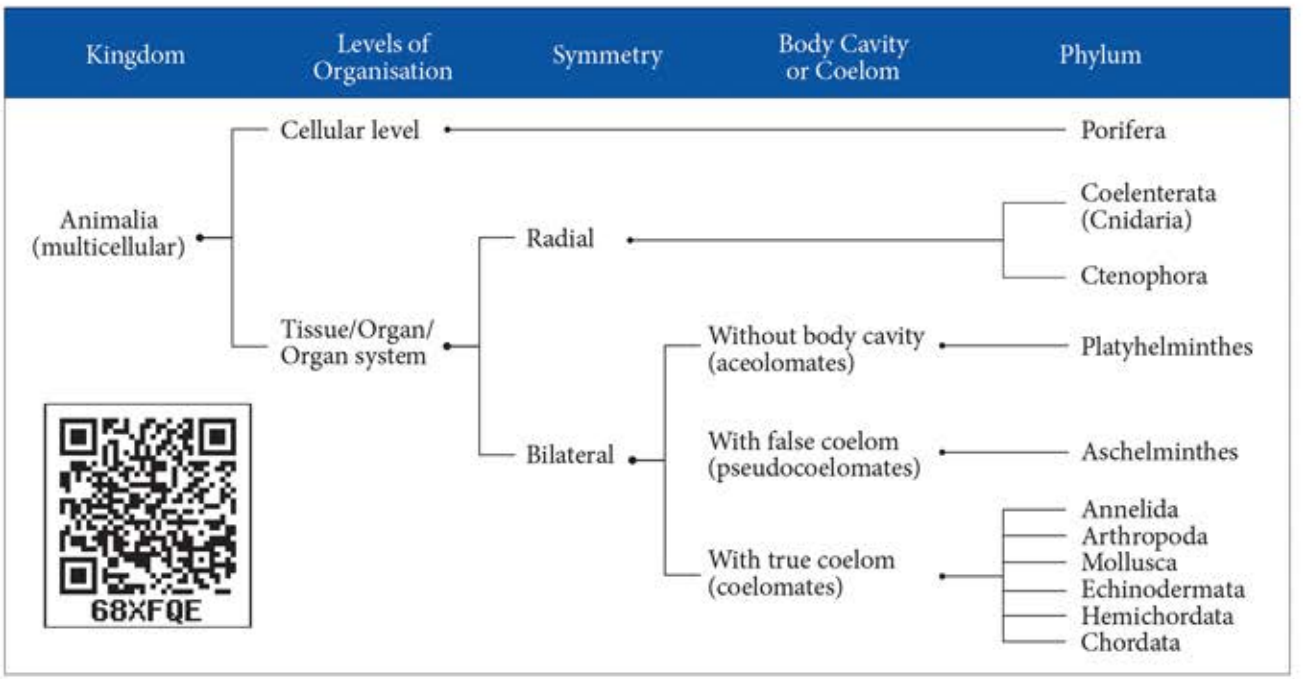


Figure 2.8 Classification of Kingdom Animalia based on common fundamental features

Examples: Cnidarians (sea anemone, jelly fish) and Ctenophores (comb jellies).

Grade: 2. Bilateria

The eumetazoans other than Radiata, show organ level of organisation and are bilaterally symmetrical and triploblastic. The grade Bilateria includes two taxonomic levels called **Division.**

Division: 1. Protostomia (*Proto*: first; *stomium*: mouth)

Protostomia includes the eumetazoans in which the embryonic blastopore develops into mouth. This division includes three subdivisions namely acoelomata, pseudocoelomata and schizocoelomata.

Division: 2. Deuterostomia (*deuteron*: secondary; *stomium*: mouth)

Eumetazoans in which anus is formed from or near the blastopore and the mouth is formed away from the blastopore. It includes only one subdivision Enterocoelomata. They have a true coelom called enterocoel, formed from the archenteron.

2.3 Non Chordates (Invertebrata)

2.3.1. Phylum: Porifera

(L. *poros*-pore; *ferre*-to bear)

These pore bearing animals are commonly called sponges. They are aquatic, mostly marine, asymmetrical and a few species live in freshwaters. They are primitive, multicellular, sessile animals with cellular level of organisation in which the cells are loosely arranged. They are either radially symmetrical or asymmetrical animals.

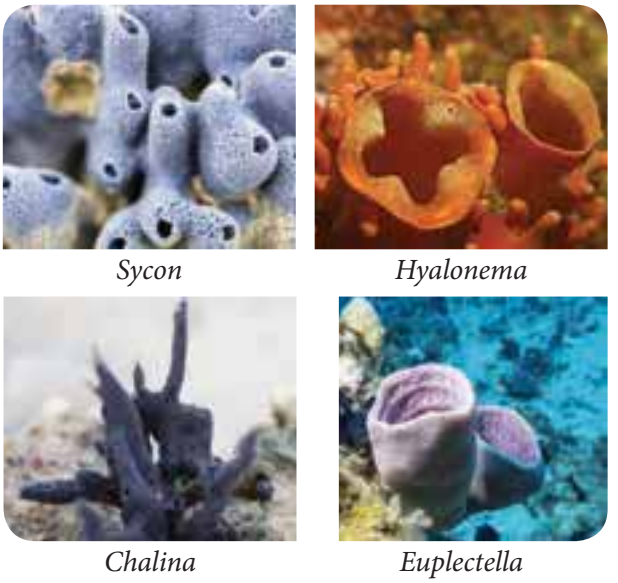


Figure 2.9 Examples of Porifera

They possess a water transport system or **canal system** where water enters through minute pores called **ostia** lining the body wall through which the water enters into a central cavity (**spongocoel)** and goes out through the osculum. This water transport system is helpful in food gathering, circulation, respiration and removal of waste. **Choanocytes** or collar cells are special flagellated cells lining the spongocoel and the canals. The body is supported by a skeleton made up of calcareous and siliceous spicules or spongin or both. Nutrition is holozoic and intracellular. All sponges are hermaphrodites (i.e.) the ova and sperms are produced by the same individual. They also reproduce asexually by fragmentation or gemmule formation and sexually by the formation of gametes. Development is indirect with different types of larval stages such as **parenchymula and amphiblastula**.

Examples: *Sycon* (Scypha), *Spongilla* (fresh water sponge), *Euspongia* (bath sponge) *Euplectella* (Venus flower basket) (Figure 2.9).

The underwater sea bed is the new habitat where the discovery and development of Marine Pharmaceuticals are in peak. Anticancerous, Antimalarial drugs and other bioactive molecules have been isolated and tested successfully.

2.3.2 Phylum: Cnidaria

(G. *knode* -needle or sting cells)

Cnidarians (were previously called Coelenterata), are aquatic, sessile or free swimming, solitary or colonial forms with radial symmetry except for sea anemones (bilateral symmetry). The name Cnidaria is derived from **cnidocytes** or **cnidoblasts** with stinging cells or nematocyst on tentacles. Cnidoblasts are used for anchorage, defense, and to capture the prey. Cnidarians are the first group of animals to exhibit tissue level organisation and are diploblastic. They have a central vascular cavity or coelenteron (serves both digestion and circulatory function) with a single opening called mouth or hypostome, which serves the process of ingestion and egestion. Digestion is both extracellular and intracellular. The nervous system is primitive and is formed of diffused nerve net. Cnidarians like corals have a skeleton made up of calcium carbonate. Cnidarians exhibit two basic body forms, polyp and medusa. The polyp forms are sessile and cylindrical (e.g. *Hydra, Adamsia*), whereas the medusa are umbrella shaped and free swimming. Cnidarians which exist in both forms, also exhibit alternation of generations in their life cycle (**Metagenesis**). The polyp represents the asexual generation and medusa represents the sexual generation. Polyps produce medusa asexually and medusa forms polyps sexually. Development is indirect and includes a free swimming ciliated **planula larva**.

Compare the advantages and disadvantage of direct and indirect development.

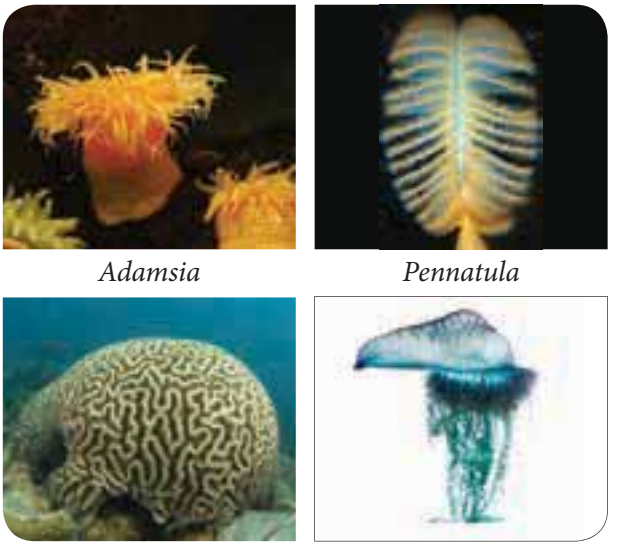


Figure 2.10 Examples of Cnidarians

Examples: *Physalia* (Portugese man of war), *Adamsia* (sea anemone), Pennatula (sea pen), *Meandrina* (brain coral) (Figure 2.10).

2.3.3 Phylum: Ctenophora

(G. *Ktenos* -comb; *phoros* -bearing)

Ctenophora are exclusively marine, radially symmetrical, diploblastic animals with tissue level of organisation. Though they are diploblastic, their mesoglea is different from that of cnidaria. It contains amoebocytes and smooth muscle cells. They have eight external rows of ciliated comb plates (comb jellies) which

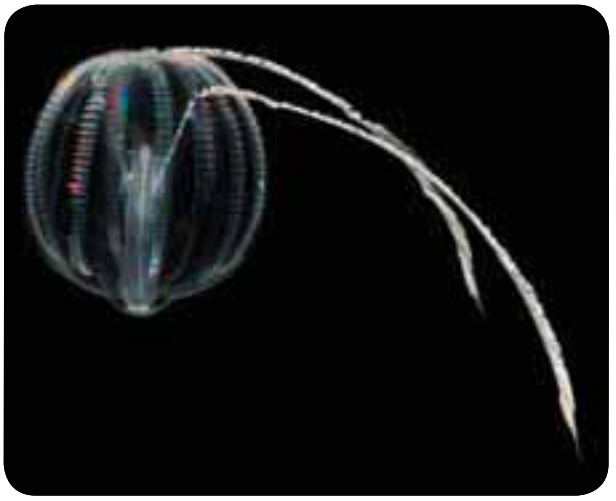


Figure 2.11 Example of Ctenophora- *Pleurobrachia*

help in locomotion, hence commonly called comb jellies or sea walnuts. Bioluminescence (the ability of a living organism to emit light) is well marked in ctenophores. They lack nematocysts but possess special cells called lasso cells or colloblasts which help in food capture. Digestion is both extracellular and intracellular. Sexes are not separate (monoecious). They reproduce only by sexual means. Fertilization is external and development is indirect and includes a larval stage called cydippid larva. e.g., *Pleurobrachia* (Figure 2.11).

Examples : *Pleurobrachia and Ctenoplana*.

2.3.4 Phylum: Platyhelminthes (Flatworms)

(G. *Platy* -broad or flat; *helmin*-worm)

They have a dorsoventrally flattened body and hence called flatworms. These animals are bilaterally symmetrical, triploblastic, acoelomate with organ system level of organisation. They show moderate cephalization and unidirectional movement. They are, mostly endoparasites of animals including human beings. Hooks and suckers are present in the parasitic forms and serve as organs of attachment. Their body is not segmented, but some exhibit pseudosegmentation. Some of the parasitic flatworms absorb nutrients directly from the host through their body surface. However, flatworms like liver fluke have an incomplete digestive system. Specialized excretory cells called flame cells help in osmoregulation and excretion. Sexes are not separate (monoecious); fertilisation is internal and development is through larval stages (miracidium, sporocyst, redia, cercaria). Polyembryony is common in some flatworms (Liver flukes). Some members like *Planaria* show high regeneration capacity (Figure 2.12).

Planaria

Liverfluke

Tapeworm

Figure 2.12 Examples of Platyhelminthes

Examples: *Taenia solium* (tape worm), *Fasciola hepatica* (liver fluke), *Schistosoma* (blood fluke).

2.3.5 Phylum: Aschelminthes (Round Worms)

(G. *Askes* –cavity; *helminths* – worms)

Previously called Nematoda, this phylum is now named as Aschelminthes. The body of these worms is circular (round) in cross section and hence are called round worms. They are free living or parasitic on aquatic and terrestrial plants and animals. They are bilaterally symmetrical, triploblastic and pseudocoelomate animals with organ system level of organisation. The body is unsegmented and covered by a transparent, tough and protective collagenous layer called cuticle. The alimentary canal is complete with a well developed mouth, muscular pharynx and anus. Excretory system consists of rennet glands. Sexes are separate; and exhibit sexual dimorphism; often females are longer than males. Fertilisation is internal; majority are oviparous (e.g. *Ascaris*) few are ovoviviparous (*Wuchereria*). Development may be direct or indirect.

Examples. *Ascaris lumbricoides* (round worm), *Enterobius vermicularis* (Pin worm), *Wuchereria bancrofti* (filarial worm), *Ancylostomaa deuodenale* (hook worm) (Figure 2.13).

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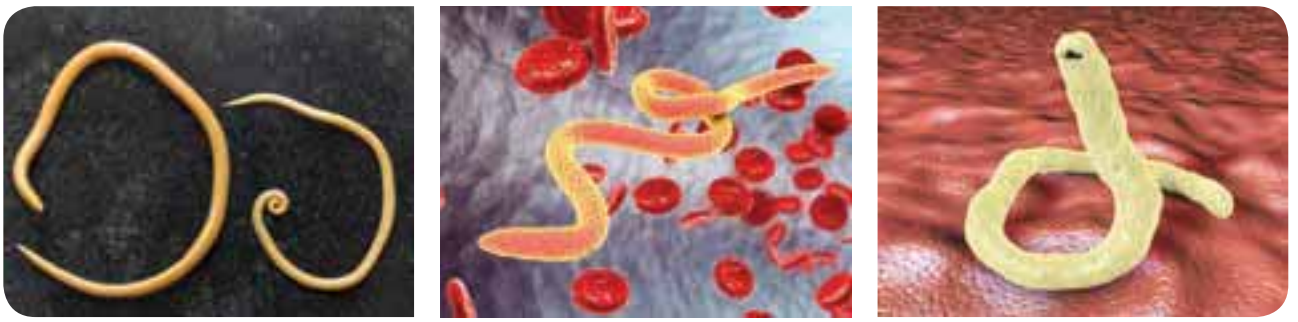
2.3.6 Phylum: Annelida (Segmented worm)

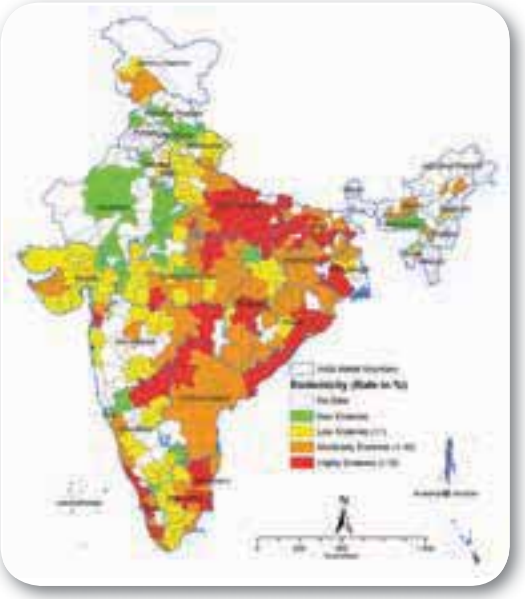
(L. *annulus* -a ring, and G. *edios*- form)

Annelids were the first segmented animals to evolve. They are aquatic or terrestrial, free living but some are parasitic. They are triploblastic, bilaterally symmetrical, schizocoelomates and exhibit organ system level of body organisation. The coelom with coelomic fluid creates a hydrostatic skeleton and aids in locomotion. Their elongated body is metamerically segmented and the body surface is divided into segment or metameres. Internally the segments are divided from one another by partitions called septa. This phenomenon is known as metamerism. The longitudinal and circular muscles in the body wall help in locomotion. Aquatic annelids like *Nereis* have lateral appendages called parapodia, which help in swimming. Chitinous setae



Ascaris *Filarial worm* *Hook worm*

Figure 2.13 Examples of Aschelminthes



Filariasis has been a major public health problem in India next only to malaria. The disease was recorded in India as early as 6th century B.C. by the famous Indian physician, Susruta in his book **Susruta Samhita.** In 7th century A.D., **Madhavakara** described signs and symptoms of the disese in his treatise ' Madhava Nidhana' which holds good even today. In 1709, Clarke identified elephantoid legs in Cochin. The microfilariae in the peripheral blood was first identified by Lewis in 1872 in Calcutta (Kolkata).

in Earthworms, and suckers in Leech help in locomotion. The circulatory system is of closed type and the respiratory pigments are hemoglobin and chlorocruorin. Nervous system consists of paired ganglion connected by the lateral nerves to the double ventral nerve cord. They reproduce sexually. Development is direct or indirect and includes a trochophore larva. Some are monoecious (earthworms) while some are dioecious (Neries and Leech). (Figure 2.14)

Examples: *Lampito mauritii* (earthworm), *Neries* (sand worm), *Hirudinaria* (leech).

How is cephalisation advantageous to animals in finding food?

2.3.7 Phylum: Arthropoda

(G. *arthros*- jointed; podes- feet)

This is the largest phylum of the Kingdom Animalia and includes the largest class called Insecta (total species ranges from 2-10 million). They are bilaterally symmetrical, segmented, triploblastic and schizocoelomate animals with organ system grade of body organisation. They have jointed appendages which are used for locomotion,

Earthworm

Nereis

Leech

Figure 2.14 Examples of Annelida

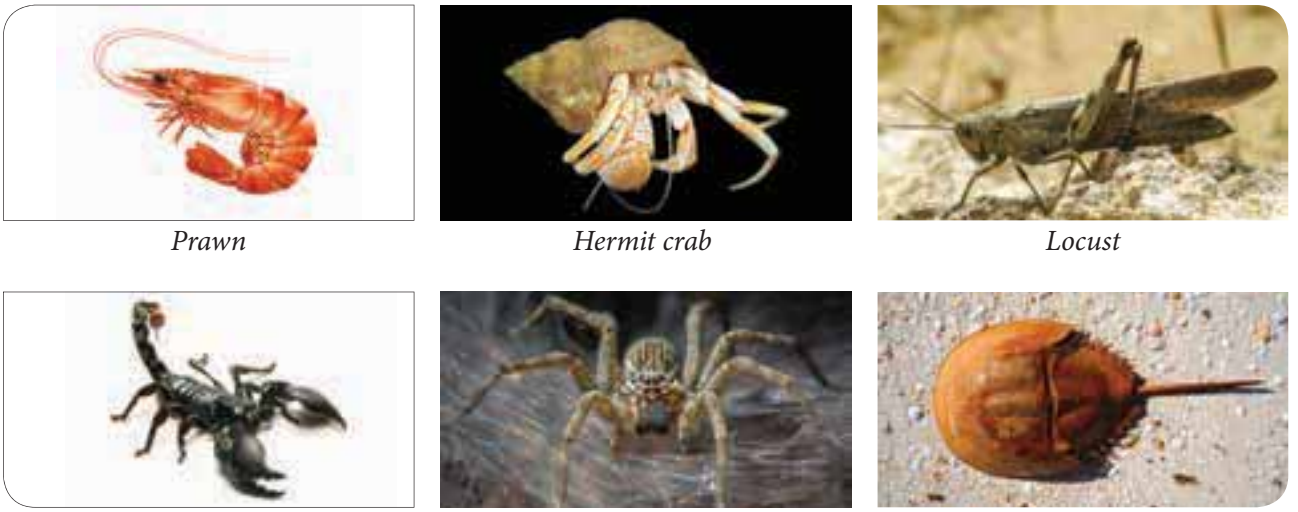


Figure 2.15 Examples of Arthropoda

feeding and are sensory in function. Body is covered by chitinous exoskeleton for protection and to prevent water loss, It is shed off periodically by a process called moulting or ecdysis. The body consists of a head, thorax, and abdomen with a body cavity called haemocoel. Respiratory organs are gills, book gills, book lungs or trachea. Circulatory system is of open type. Sensory organs like antennae, eyes (compound and simple), statocysts (organs of balance/ equilibrium) are present. Excretion takes place through malpighian tubules, green glands, coxal glands, etc. They are mostly dioecious and oviparous; fertilization is usually internal. Development may be direct or indirect. Life history includes many larval stages followed by metamorphosis.

Examples : *Limulus* (King crab, a living fossil), *Palamnaeus* (Scorpion), *Eupagarus* (Hermit crab), *Apis* (Honey bee), *Musca* (House fly), Vectors- *Anopheles*, *Culex*, *Aedes* (mosquitoes), Economically important insects - *Apis*- (Honey bee), *Bombyx* (Silk worm), *Laccifer* (Lac insects), Living fossils *Limulus*- (King crab), Gregarious pest - *Locusta* (Locust) (Figure 2.15)

2.3.8 Phylum: Mollusca

(L. *molluscs* –soft bodied)

This is the second largest animal phylum. Molluscs are terrestrial or aquatic (marine or fresh water) and exhibit organ system level of body organisation. They are bilaterally symmetrical (except univalves), triploblastic and coelomate animals. Body is covered by a calcareous shell and is unsegmented with a distinct head, muscular foot and a visceral hump or visceral mass. A soft layer of skin forms a mantle over the visceral hump. The space between the visceral mass and mantle (pallium) is called the mantle cavity in which a number of feather like gills (**ctenidia)** are present, which are respiratory in function. The

Spider silk is five times stronger than steel of the same diameter. It has been suggested that a Boeing 747 could be stopped in flight by a single pencil-width strand and spider silk is almost as strong as Kevlar, the toughest man-made polymer.

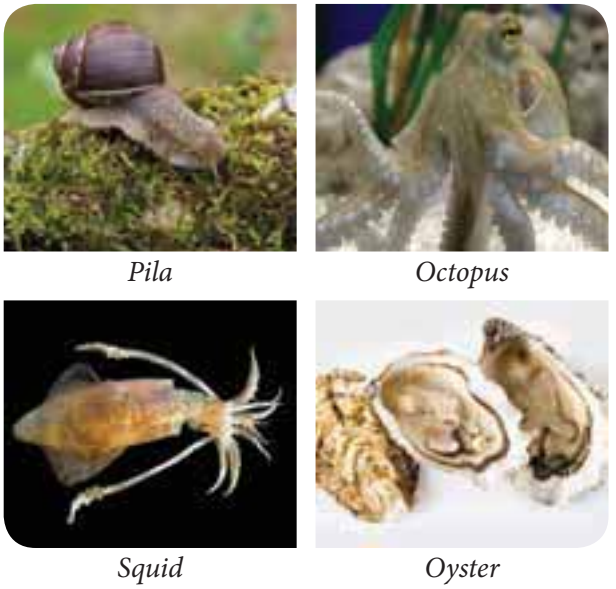


Figure 2.16 Examples of Mollusca

digestive system is complete and mouth contains a rasping organ called radula with transverse rows of chitinous teeth for feeding (radula is absent in bivalves. The sense organs are tentacles, eyes and ospharidium (to test the purity of water and present in bivalves and gastropods). Excretory organs are nephridia. Open type of circulatory system is seen except for cephalopods such as squids, cuttle fishes and octopuses. Blood contains haemocyanin, a copper containing respiratory pigment. They are dioecious and oviparous. Development is indirect with a veliger larva (a modified trochophore larva).

Examples: *Pila* (Apple snail), *Lamellidens* (Mussel), *Pinctada* (Pearl oyster), *Sepia* (Cuttle fish), *Loligo* (Squid), *Octopus* (Devil fish) (Figure 2.16).

DO YOU KNOW?

Marbled Cone Snail
(*Conus marmoreus*)

This cone-shaped snail can deliver dangerous venom which may result in vision loss, respiratory failure, muscle paralysis and eventually death. There is no anti-venom available.

2.3.9 Phylum Echinodermata

(G. *Echinos* – spiny; *dermos* –skin)

All Echinoderms are marine animals. The adults are radially symmetrical but the larvae are bilaterally symmetrical. These animals have a mesodermal endoskeleton of calcareous ossicles and hence the name Echinodermata (spiny skin). They are exclusively marine with organ system level of organisation. The most distinctive feature of echinoderms is the presence of the water vascular system or ambulacral system with tube feet or podia, which helps in locomotion, capture and transport of food and respiration. The digestive system is complete with mouth on ventral side and anus on the dorsal side. Excretory organs are absent. The nervous system and sensory organs are poorly developed. The circulatory system is

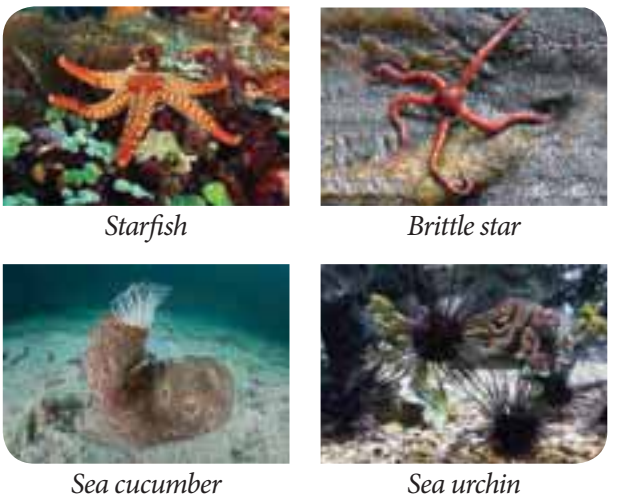


Figure 2.17 Examples of Echinodermata

open type without heart and blood vessels. Sexes are separate. Reproduction is sexual and fertilization is external. Development is indirect with free swimming bilaterally symmetrical larval forms. Some echinoderms exhibit autotomy with remarkable powers of regeneration. (Figure 2.17)

Examples: *Asterias* (Starfish or sea star), *Echinus* (Sea-urchin), *Antedon* (Sea-lily), *Cucumaria* (Sea-cucumber), *Ophiura* (Brittle star)

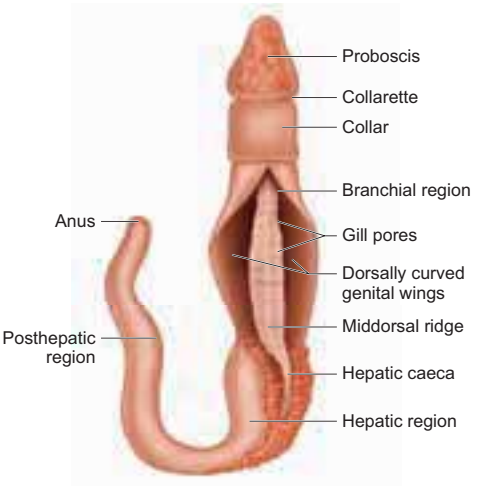
2.3.10 Phylum: Hemichordata

(G.*hemi* –half; *chorde*-string)

Hemichordates were earlier treated as a subphylum of Chordata (or Prochordata). They are now regarded to be an independent phylum of invertebrates, close to Echinodermata. The animals of this group possess the characters of invertebrates as well as chordates.

This phylum consists of a small group of worm-like, soft marine animals, mostly tubiculous and commonly called the 'acorn worms' or 'tongue worms'. They are bilaterally symmetrical, triploblastic and coelomate animals with organ system level of organisation. Their body is cylindrical and is divided into three regions, the anterior proboscis, a short collar and a long trunk. Most hemichordates are ciliary feeders. Their circulatory system is simple and open or lacune type with a dorsal heart. Respiration is through paired gill slits opening into the pharynx. Excretion is by a single proboscis gland or glomerulus situated in the proboscis. Nervous system is primitive. Sexes are separate and exhibit sexual mode of reproduction; Fertilization is external. Development is indirect with a free swimming tornaria larva.

Balangoglossus



Diagrammatic representation of Balanoglossus

Figure 2.18 Example of Hemichordata

Examples: *Balanoglossus*, *Saccoglossus*, *Ptychodera flava* (Indian Hemichordate found in Kurusadai islands in Tamilnadu) (Figure 2.18).

2.4 Phylum: Chordata

(G. *Chorda –string*)

Chordata is the largest phylum with most familiar group of animals, such as fishes, amphibians, reptiles, birds and mammals and less known forms such as lancelets (Amphioxus) and tunicates (Ascidian). All chordates possess three fundamental distinct features at some stage of their life cycle (Figure 2.19), they are:

1. Presence of elongated rod like notochord below the nerve cord and above the alimentary canal. It serves as a primitive internal skeleton. It may persist throughout life in lancelets and lampreys. In adult vertebrates, it may be partially or completely replaced by backbone or vertebral column.
2. A dorsal hollow or tubular fluid filled nerve cord lies above the notochord and below the dorsal body wall. It serves to integrate and co-ordinate the body functions. In higher chordates, the anterior end of the nerve cord gets enlarged to form the brain and the posterior part becomes the spinal cord, protected inside the vertebral column.
3. Presence of pharyngeal gill slits or clefts in all chordates at some stage of their lifecycle. It is a series of gill slits or clefts that perforates the walls of pharynx and appears during the development of every chordate. In aquatic forms, pharyngeal gill slits are vascular, lamellar and form the gills for respiration. In terrestrial chordates, traces of non-functional gill clefts appear during embryonic developmental stages and disappear later. Besides the above said features, chordates are bilaterally symmetrical, triploblastic, coelomates with organ system level of organisation; they possess post anal tail, closed circulatory system with a ventral myogenic heart except in *Amphioxus*.

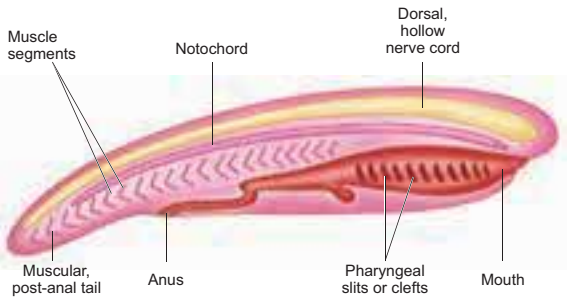


Figure 2.19 A Typical Chordate

2.4.1. Subphylum: Urochordata or Tunicata

(G. *Oura* – A tail; L. *Chord* – cord)

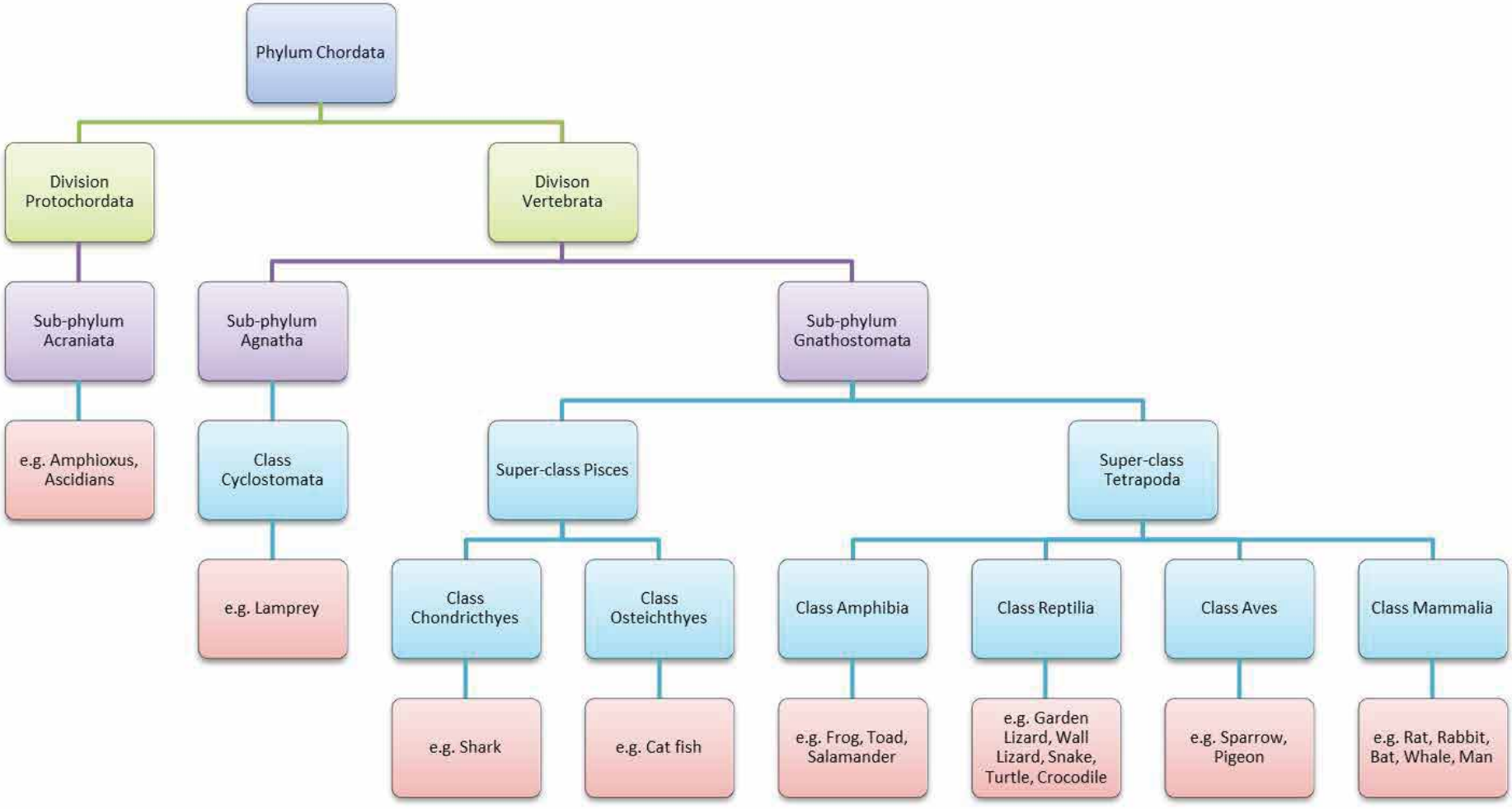
They are exclusively marine and are commonly called sea squirts. Mostly sessile, some pelagic or free swimming, exist as solitary and colonial forms. Body is unsegmented and covered by a test or tunic. Adult forms are sac like. Coelom is absent, but has an atrial cavity surrounding

Table. 1. Comparison of chordates and non-chordates

Chordates	Non-chordates
Notochord is present	Absence of notochord
Dorsal, hollow and single nerve cord	Double ventral solid nerve cord
Pharynx perforated by gill slits	Gill slits absent
Heart is ventrally placed	Heart is dorsal or laterally placed or absent
A post anal tail is present	Post anal tail is absent
Alimentary canal placed ventral to the nerve cord	Alimentary canal is placed dorsal to the nerve cord

List the three features common to all chordates at sometime in their life.

Figure 2.20 Classification of Phylum Chordata



Ascidia

Salpa

Doliolum

Figure 2.21 Examples of Urochordata

the pharynx. Notochord is present only in the tail region of the larval stage, hence named urochordata. Alimentary canal is complete and circulatory system is of open type. The heart is ventral and tubular. Respiration is through gill slits and clefts. Dorsal tubular nerve cord is present only in the larval stage and a single dorsal ganglion is present in the adults. Mostly hermaphrodites, development indirect and includes a free swimming tadpole larva with chordate characters. Retrogressive metamorphosis is seen (Figure 2.21).

Examples: *Ascidia, Salpa, Doliolum*

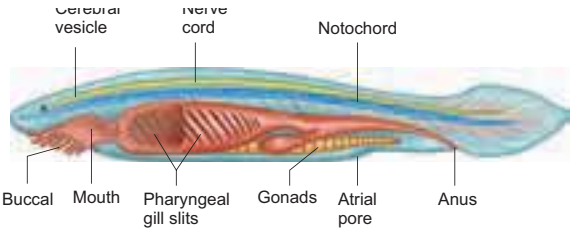
2.4.2. Subphylum: Cephalochordata

(L. *Cephalo*- 'head' ; G. *chorda* 'cord'.)

Cephalochordates are marine forms, found in shallow waters, leading a burrowing mode of life. They are small fish like coelomate forms with chordate characters such us notochord, dorsal tubular nerve cord and pharyngeal gill slits throughout their life. Closed type of circulatory system is seen without heart. Excretion is by protonephridia. Sexes are separate, Fertilization is external. Development is indirect and includes a free swimming larva (Figure 2.22).

Example: *Branchiostoma* (Amphioxus or lancelet)

Amphioxus



Internal sturcutre of Amphioxus

Figure 2.22 Example of Cephalochordata

2.4.3. Subphylum-Vertebrata

(L. *Vertebrus* –back bone)

Vertebrates are also called higher chordates and they possess notochord during embryonic stage only. The notochord is replaced by a cartilaginous or bony vertebral column in the adult. **Hence all vertebrates are chordates but all chordates are not vertebrates.** Vertebrates possess paired appendages such as fins or limbs. Skin is covered by protective skeleton comprising of scales, feathers, hairs, claws, nails,

etc. Respiration is aerobic through gills, skin, buccopharyngeal cavity and lungs. Vertebrates have a ventral muscular heart with two, three or four chambers and kidneys for excretion and osmoregulation.

Subphylum Vertebrata is divided into two divisions, **Agnatha** and **Gnathostomata**. Agnatha includes jawless fish-like aquatic vertebrates without paired appendages. Notochord persists in the adult. Gnathostomata includes jawed vertebrates with paired appendages. Notochord is replaced partly or wholly by the vertebral column. Agnatha includes one important class – Cyclostomata. Gnathostomata includes jawed fishes (Pisces) and Tetrapoda (amphibia, reptilia, aves and mammals). The superclass Pisces includes all fishes which are essentially aquatic forms with paired fins for swimming and gills for respiration. Pisces includes cartilaginous fishes (Chondrichthyes) and bony fishes (Osteicthyes).

2.4.4. Class: Cyclostomata

(G.*cyklos*–circle; *stomata* -mouth)

All members of cyclostomata are primitive, poikilothermic, jawless aquatic vertebrates and are ectoparasites on some fishes. Body is slender and eel-like bearing six to fifteen pair of gill slits for respiration. Mouth is circular without jaws and suctorial. Heart is two chambered and circulation is of closed type. No paired appendages. Cranium and vertebral column are cartilaginous. Cyclostomes are marine but migrate to fresh waters for spawning (anadromous migration). After spawning within a few days they die. The larvae (ammocoete) after metamorphosis returns to the ocean. Examples: *Petromyzon* (Lamprey) and *Myxine* (Hag fish) (Figure 2.23).

Lamprey *Hagfish*

Figure 2.23 Examples of Cyclostomata

2.4.5. Class: Chondrichthyes

(*G. chondros* –cartilage; *ichthys* -fish)

They are marine fishes with cartilaginous endoskeleton. Notochord is persistent throughout life. Skin is tough covered by dermal **placoid scales** and the caudal fin is **heterocercal** (asymmetrical both externally and internally). Mouth is located ventrally and teeth are modified placoid scales which are backwardly directed. Their jaws are very powerful and are predaceous animals. Respiration by **lamelliform gills** without operculum (gill cover). Excretory organs are **mesonephric** kidneys. Two chambered heart is present. Cartilaginous fishes are ureotelic and store urea in their blood to maintain osmotic concentration of body fluids. They are **poikilothermic** and **viviparous**. Sexes are separate. In males pelvic fins bear claspers to aid in internal fertilisation.

Examples: *Scoliodon* (Shark), *Trygon* (Sting ray), *Pristis* (Saw fish) (Figure 2.24).

2.4.6. Class: Osteichthyes

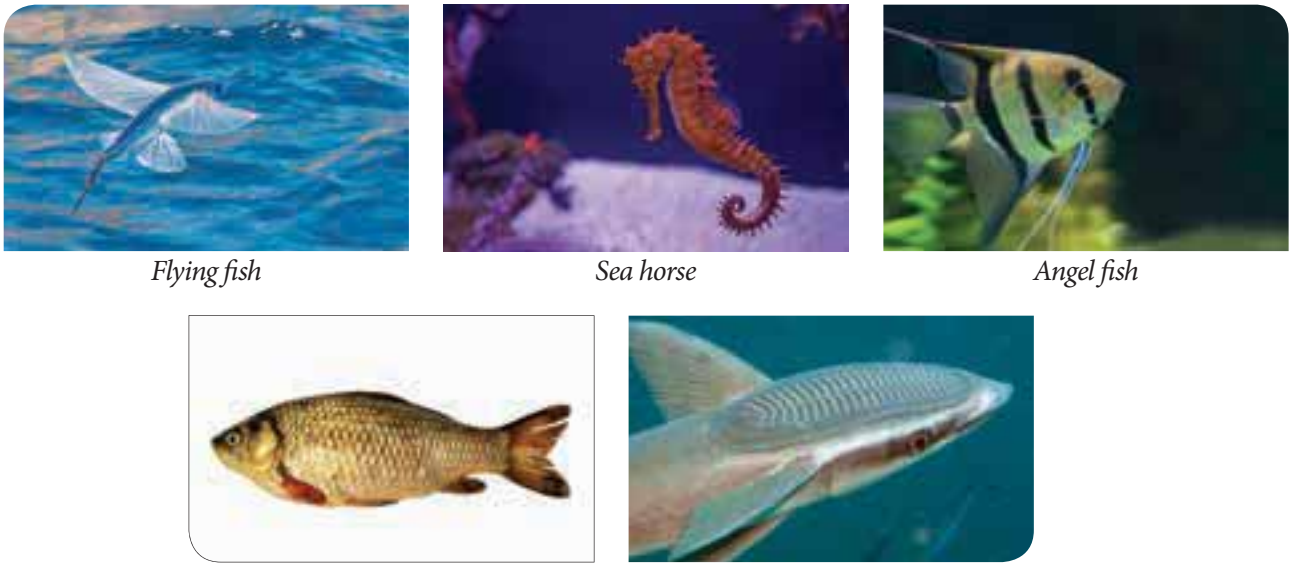
(G. *osteon* –bone; *ichthys* -fish)

It includes both marine and freshwater fishes with bony endoskeleton and spindle shaped body. Skin is covered by ganoid, cycloid or ctenoid scales. Respiration is by four pairs of filamentous gills and is covered by an operculum on either side. Air bladder is present with or without a connection to the gut. It helps in gaseous exchange (lung fishes) and for maintaining buoyancy in most of the ray finned fishes. They have a ventrally placed two chambered heart. Excretory organs are mesonephric kidneys and are ammonotelic. Presence of well developed lateral line sense organ. Sexes are separate, external fertilization is seen and most forms are oviparous (Figure 2.25).

Examples: *Exocoetus* (Flying fish), *Hippocampus* (Sea horse), *Labeo* (Rohu), *Catla* (Catla), *Echeneis* (Sucker fish), *Pterophyllum* (Angel fish)

Shark *Pristis* *Sting ray*

Figure 2.24 Examples of Chondrichthyes



Flying fish *Sea horse* *Angel fish*

Carp *Sucker fish*

Figure 2.25 Examples of Osteichthyes

Frog

Toad

Salamander

Icthyophis (Caecilians)

Figure 2.26 Examples of Amphibia

2.4.7. Class: Amphibia

(G. *amphi*-both; *bios* -life)

Amphibians are the first vertebrates and tetrapods to live both in aquatic as well as terrestrial habitats.They are poikilothermic. Their body is divisible into the head and trunk and most of them have two pairs of limbs; tail may or may not be present. Their skin is smooth or rough, moist, pigmented and glandular. Eyes have eyelids and the tympanum represents the ear. Respiration is by gills, lungs and through the skin. Heart is three chambered. Kidneys are **mesonephric.** Sexes are separate and fertilization is external. They are oviparous and development is indirect. They show hibernation and aestivation.

Examples: *Bufo* (Toad), *Rana* (Frog), *Hyla* (Tree frog), *Salamandra* (Salamander), *lcthyophis* (Limbless amphibians) (Figure 2.26).

2.4.8. Class: Reptilia

(*L. repere* or *reptum* – to creep or crawl)

They are mostly terrestrial animals and their body is covered by dry, and cornified skin with epidermal scales or scutes. Reptiles have three chambered heart but four chambered in crocodiles. All are cold blooded amniotes (poikilotherms). Most reptiles lay **cleidoic eggs** with extraembryonic membranes like amnion, allantois, chorion and yolk sac. Excretion by metanephric kidneys and are uricotelic. They are monoecious. Internal fertilization takes place and all are oviparous.

Examples : *Chelone* (Turtle), *Testudo* (tortoise), *Hemidactylus* (House lizard), *Chameleon* (Tree lizard), *Calotes* (Garden lizard), *Draco* (Flying lizard), *Crocodilus* (crocodile), Poisonous snakes - *Naja* (Cobra), *Bangarus* (Krait), *Vipera* (Viper) (Figure 2.27).

King cobra

Draco (Flying Lizard)

Crocodile

Chameleon

Figure 2.27 Examples of Reptiles

TURTLE Vs TORTOISE

Turtles spend most of their life in the water
Carapace is laterally compressed and streamlined.
Mostly live in the water or are always found near it.
Most of them have webbed feet.

Tortoises spend most of their life on land.
Carapace is usually dome-shaped.
Are primarily terrestrial.
Feet are short and sturdy with bent legs.

2.4.9. Class Aves

(L. *Avis* –bird)

Aves are commonly known as birds. The characteristic feature of Aves is the presence of feathers and the ability to fly except for flightless birds (Eg. *Ostrich, Kiwi, Penguin*). The forelimbs are modified into wings, and the hind limbs are adapted for walking, running, swimming and perching. The skin is dry and devoid of glands except the oil gland or preen gland at the base of the tail. The exoskeleton consists of epidermal feathers, scales, claws on legs and the horny covering on the beak. The endoskeleton is fully ossified (bony) and the long bones are hollow with air cavities (pneumatic bones). The pectoral muscles of flight (pectoralis major and pectoralis minor) are well developed. Respiration is by compact, elastic, spongy lungs that are continuous with air sacs to supplement respiration. The heart is four chambered. Aves are homeothermic. Migration and parental care is well marked. Urinary bladder is absent. Sexes are separate with well marked sexual dimorphism. In males, the testes are paired but in females, only the left ovary is well developed while the right ovary is atrophied. All birds are oviparous. Eggs are megalecithal and cleidoic. Fertilization is internal.

Examples *Corvus* (Crow), *Columba* (Pigeon), *Psittacula* (Parrot), *Pavo* (Peacock), *Aptenodytes* (Penguin), *Neophron* (Vulture), *Chalcophaps indica* (Tamilnadu state bird, Common Emerald Dove) (Figure 2.28).

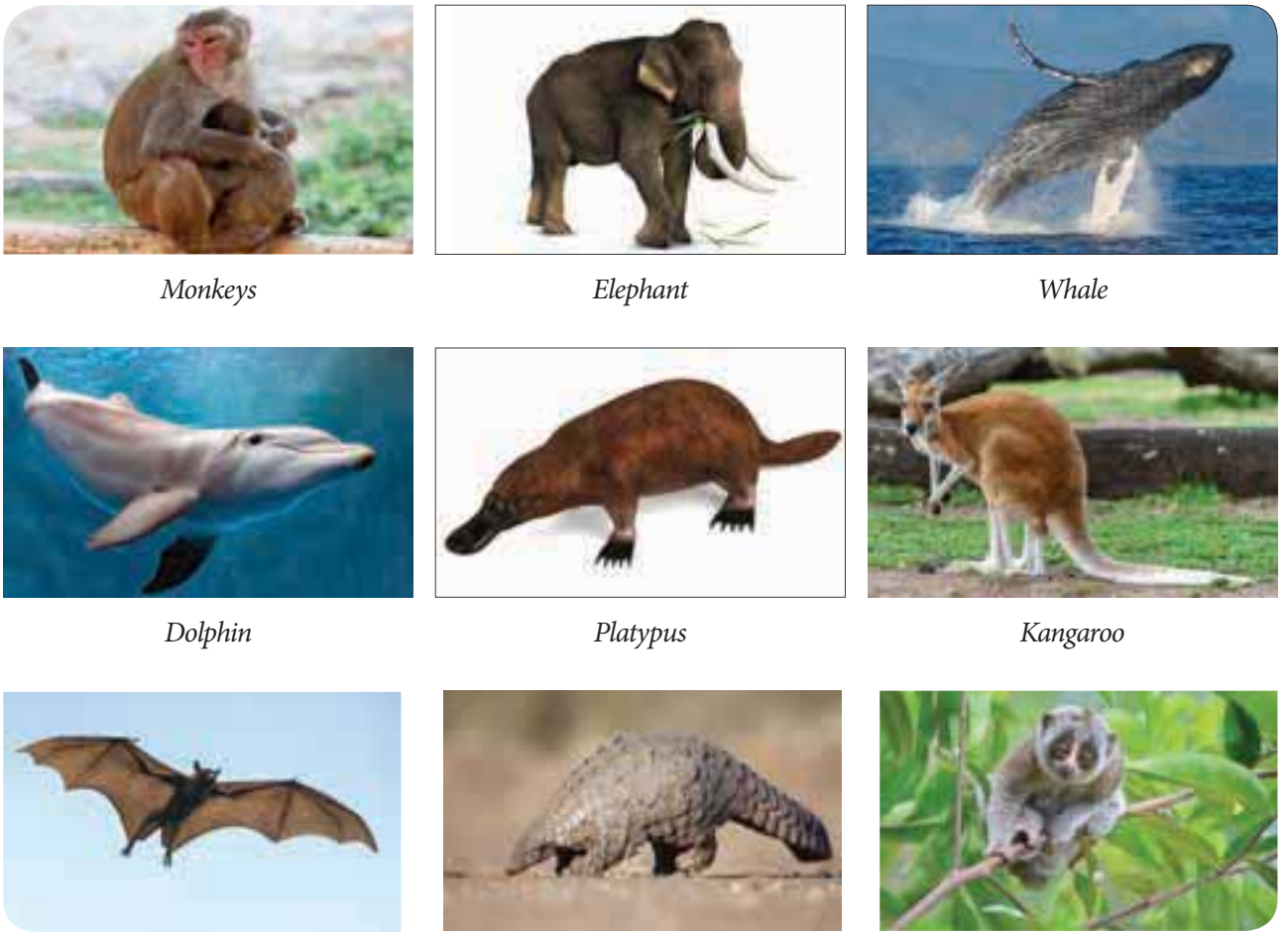
DO YOU KNOW?

Hooded Pitohui

(*Pitohui dichrous*)

The Hooded Pitohui is a songbird found in the rain forests of New Guinea, The first poisonous bird to be documented A neurotoxin called Homobatrachotoxin is found in its skin and feathers, causes numbness and tingling in those touching the bird.

Figure 2.28 Examples of Aves



Monkeys *Elephant* *Whale*

Dolphin *Platypus* *Kangaroo*

Bat *Pangolin* *Loris*

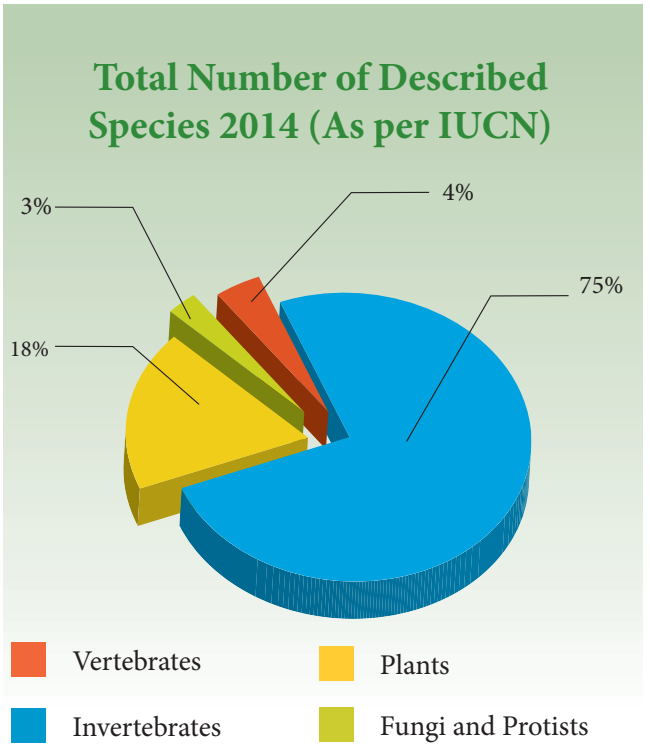
Figure 2.29 Examples of Mammals

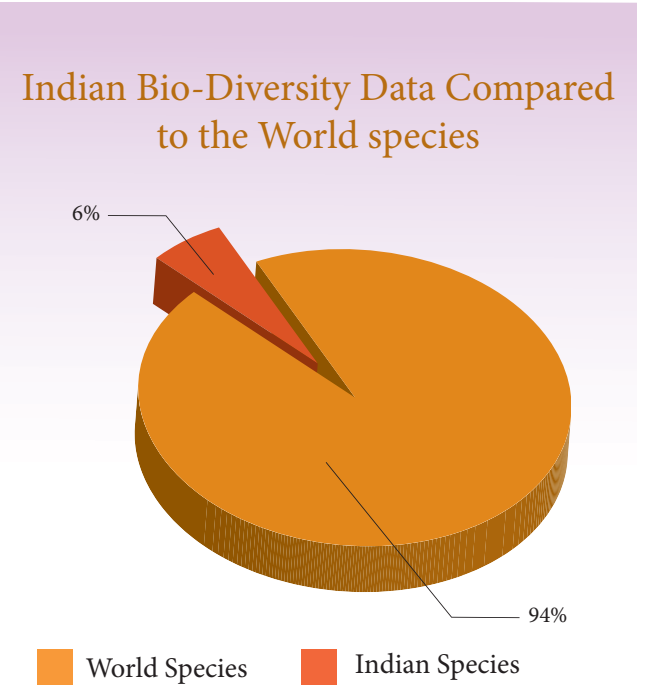
2.4.10. Class: Mammalia

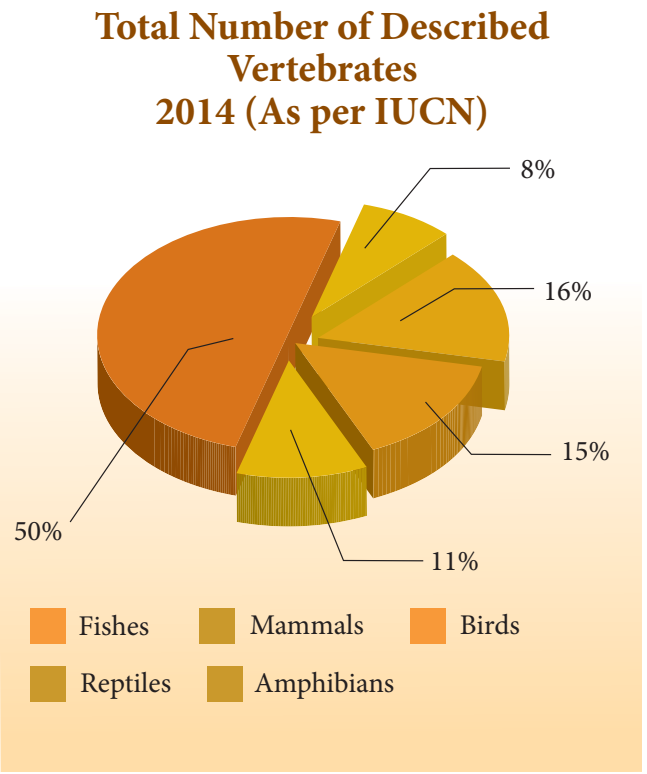
(L. *Mamma* – Breast)

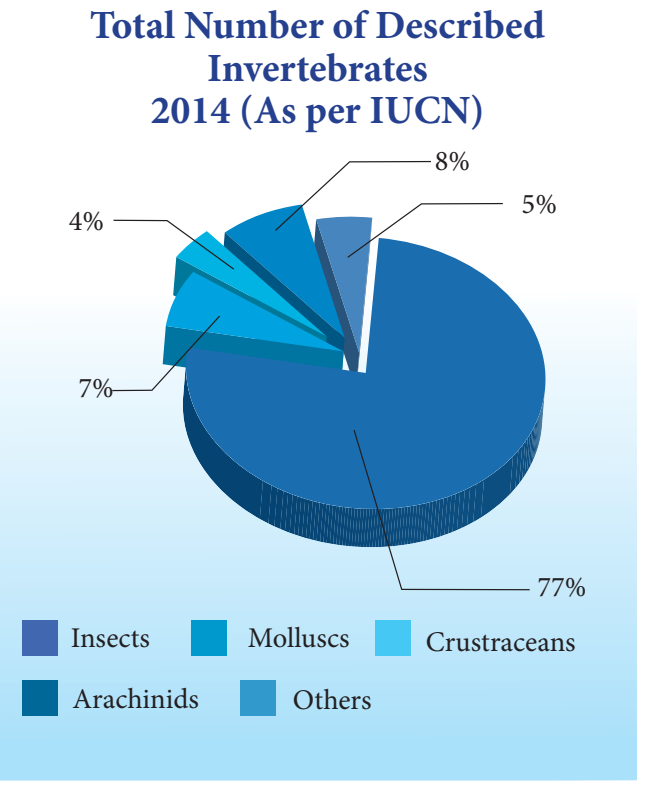
They are found in a variety of habitats. Their body is covered by hair, a unique feature of mammals. Some of them are adapted to fly or live in water. Presence of mammary glands is the most unique feature of mammals. They have two pairs of limbs adapted for walking, running, climbing, burrowing, swimming and flying. Their skin is glandular in nature, consisting of sweat glands, scent glands and sebaceous glands. Exoskeleton includes horny epidermal horns, spines, scales, claws, nails, hooves and bony dermal plates. Teeth are thecodont, heterodont and diphyodont. External ears or pinnae are present. The heart is four chambered and possess a left systematic arch. Mature RBCs are circular, biconcave and non nucleated. Mammals have a large brain when compared to other animals They show greatest intelligence among all animals. Their kidneys are metanephric and are ureotelic. All are homeothermic, sexes are separate and fertilization is internal.

Examples Oviparous- *Ornithorhynchus* (Platypus), Viviparous- *Macropus* (Kangaroo), *Pteropus* (Flying fox), *Macaca* (Monkey), *Canis* (Dog), *Felis* (Cat), *Elephas* (Elephant), *Equus* (Horse), *Delphinus* (Common dolphin) *Balaenoptera* (Blue whale), *Panthera tigris* (Tiger), *Panther leo* (Lion), *Homo sapiens* (Human) *Bos* (Cattle).









Activity

Objectives:

Some Groups of organisms with their distinguishing characteristics are given. Construct a cladogram, interpret and analyze the cladogram in terms of how it shows common ancestry and degrees of evolutionary relationship.

Procedure:

Step 1. Refer your text book and identify the characteristics of the given animals. In the data table provided, place an "x" in the box if the animal has the characteristic.

Step 2: Below the Data Table on the Worksheet, make a Venn diagram, placing animals in groups to illustrate those characteristics which different animals have in common.

Step 3: Using the Venn diagram draw a cladogram to illustrate the ancestry of these animals. The diagram should reflect the shared characteristics as time proceeds.

Step 4: Draw the Venn diagram to reflect the shared characteristics of the given animal and draw a cladogram.

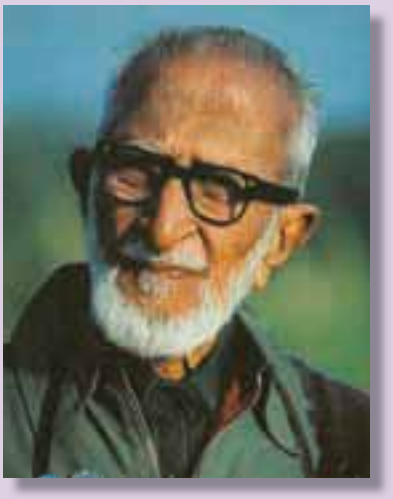






Sets	Traits	Kangaroo	Lamprey	Monkey	Frog	Human	Tortoise	Fish
Set#1	Dorsal Nerve cord, Notochord							
Set#2	Paired Appendages Vertebral column							
Set#3	Paired legs							
Set#4	Amnion (Amniotic sac)							
Set#5	Mammary gland							
Set#6	Placenta							
Set#7	Canine teeth							
	Total 'X' s							

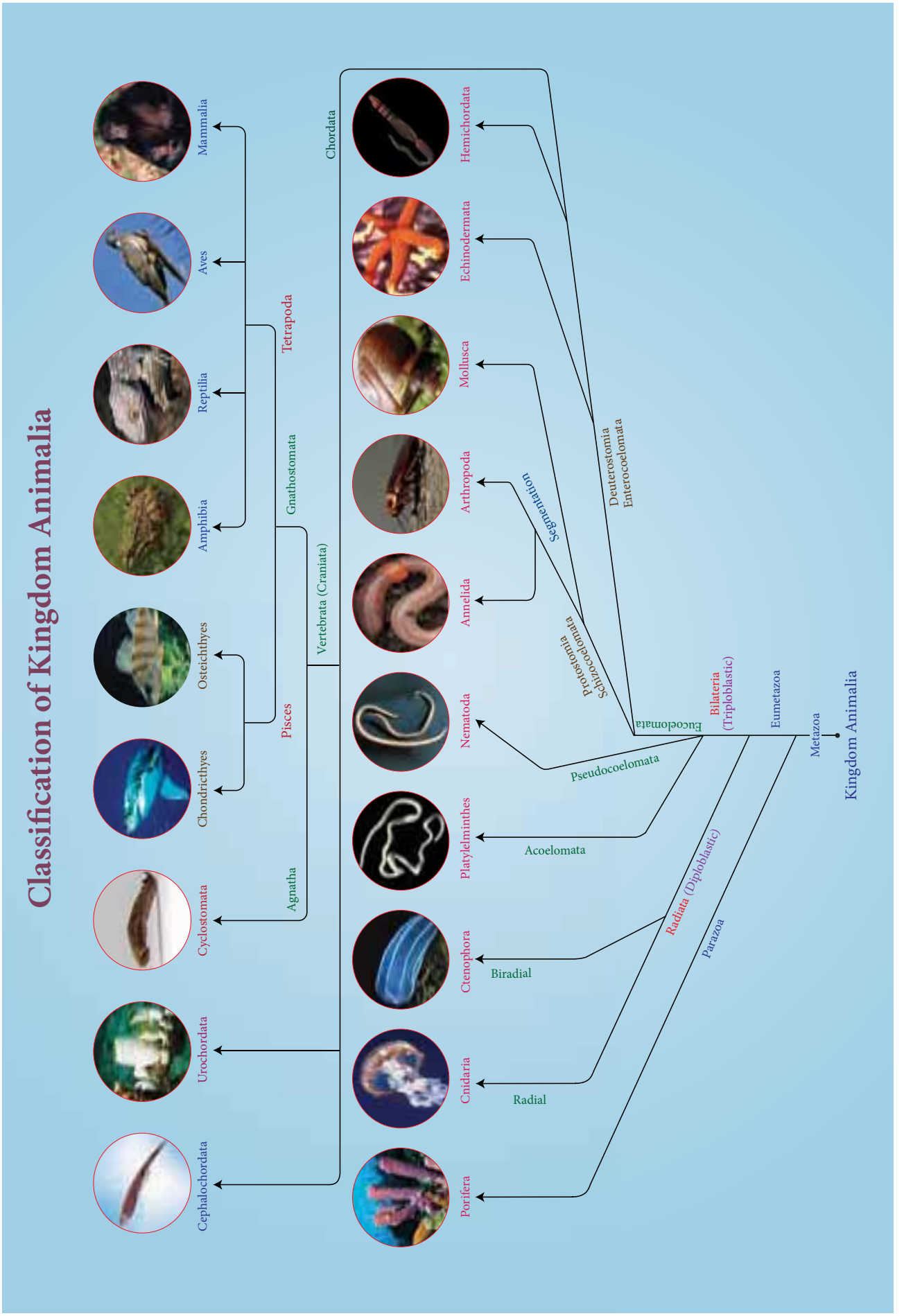
CASE STUDY



Sálim Moizuddin Abdul Ali is the leading pioneer of Indian Ornithology and generally referred as Bird Man of India. He was born on 12 November 1896 in Bombay and he was the most respected and influential naturalist of 20th century in India, He passed away on 20 June 1987. Young Salim got interested in birds when he was at the age of ten. Later he has conducted many systematic bird surveys across India and the neighboring countries. He authored many bird books and popularized ornithology in India. 'Book of Indian birds' and the 'Hand book of Birds of India and Pakistan' are the most important books he has written. His autobiography 'Fall of a sparrow' narrates the beginning and experience of his life with birds. Government of India honoured him with the award of Padma Bhusahan in 1958 and Padma Vibhushan 1976. He was nominated to Rajyasabha in 1985. Salim Ali through his books motivated thousands of people to the field of ornithology and natural history. Most of the environmentalists in India trace back their initial motivation to bird watching and Salim Ali's books.

In 1990, Government of India started a national research institution in his honour called Sálim Ali Centre for Ornithology and Natural History (SACON) in Coimbatore, Tamil Nadu. SACON is a Centre of excellence in research supported by the Ministry of Environment, Forest and Climate Change, Government of India. All the researches and activities of SACON is devoted to the cause of conservation of India's Biodiversity with focus on birds. The main campus of SACON is situated in the sylvan surrounding of Anaikatty, 24 kilometers northwest of Coimbatore city, within the Nilgiri Biosphere Reserve. SACON's mission is to help conserve India's biodiversity and its sustainable use through research, education and people's participation with birds at the centre stage. SACON conducts research in Ornithology covering all aspects of biodiversity and natural history. More than 50 research scholars have completed PhD in Ornithology and Natural history from SACON in its 25 years of existence. SACON is known for its many research papers published in national and international journals. Nature Education programme of SACON is very popular in the region which is inculcating love for birds and nature to thousands of people especially to school children every year. Children's Ecology Congress of SACON and Salim Ali Trophy Nature Competitions are flagship events. Salim Ali Naturalist Forum of SACON is the people's bird watching movement in Coimbatore facilitated by SACON.

Sourced from SACON (2018)



ICT Corner

Cladogram

Let's do this activity to know about **Cladogram**.

Step – 1

Type the URL given below in the browser. Press 'Play Game' button then use your personal or school id to login. Otherwise use Guest Pass to enter and start the activity.

Step – 2

Initially you will be provided with two species and their characteristics. You should drag them into the small box provided and match them.

Step – 3

Use the mouse to drag and place the characteristics on the tree.

Step – 4

If you correctly match the tree, the game will proceed to the next level. If you fail to match them start from the beginning and play the game again until you learn the characteristics.

Step 1

Step 2

Step 3

Step 4

Evolution Lab's URL:

http://www.pbs.org/wgbh/nova/labs/lab/evolution/

B167_STD_11_ZOOLOGY_EM

* Pictures are indicative only

Summary

Kingdom Animalia comprises of a broad range of animal species, from tiny parasitic nematodes to the largest mammal the blue whale. The basic fundamental features such as levels of organisation, diploblastic and triploblastic organisation, patterns of symmetry, coelom, segmentation and notochord have enabled us to broadly classify the animal kingdom. Besides the fundamental features, there are many other distinctive characters which are specific for each phyla or class.

Animals are broadly classified into invertebrates and chordates. The animals which lack vertebral column are called invertebrates. The chordates are characterized by the presence of notochord, solid ventral nerve cord and gill slits. Kingdom Animalia are classified into eleven animal phyla as Porifera, Cnidaria, Ctenophora, Platyhelminthes, Aschelminthes, Annelida, Arthropoda, Mollusca, Echinodermata, Hemichordata and Chordata. Chordata is the largest phylum with three sup phyla Urochordata, Cephalochordata and Vertebrata. Subphylum Vertebrata includes two divisions, Agnatha and Gnathostomata. Agnatha comprises of the class Cyclostomata. Gnathostomata includes jawed fishes (Pisces) and Tetrapoda which includes the classes amphibia, reptilia, aves and mammals.

Glossary

Alternation of generation – Alternation of haploid sexual and diploid asexual generation in the life cycle of an animal.

Autonomy – Breaking of a body part.

Dioecious – Animals in which male and female reproductive organs occur in separate individuals.

Hermaphrodite – Animals with both male and female reproductive organs.

Mersentery – A thin double walled epithelial membrane that support alimentary canal and other organs in the abdominal cavity.

Regeneration – Act of growing a new body part which has been injured or lost.

Evaluation

1. The symmetry exhibited in cnidarians is
   a. Radial b. Bilateral
   c. Pentamerous radial d. Asymmetrical
2. Sea anemone belongs to phylum
   a. Protozoa b. Porifera
   c. Coelenterata d. Echinodermata
3. The excretory cells that are found in platyhelminthes are
   a. Protonephridia b. Flame cells
   c. Solenocytes d. All of these
4. In which of the following organisms, self fertilization is seen.
   a. Fish b. Round worm
   c. Earthworm d. Liver fluke
5. Nephridia of Earthworms are performing the same functions as
   a. Gills of prawn
   b. Flame cells of Planaria
   c. Trachea of insects
   d. Nematoblasts of Hydra

6. Which of the following animals has a true coelom ?
   a. *Ascaris* b. *Pheretima*
   c. *Sycon* d. *Taenia solium*
7. Metameric segmentation is the main feature of
   a. Annelida b. Echinodermata
   c. Arthropoda d. Coelenterata
8. In *Pheretima* locomotion occurs with help of
   a. circular muscles
   b. longitudinal muscles and setae
   c. circular, longitudinal muscles and setae
   d. parapodia
9. Which of the following have the highest number of species in nature?
   a. Insects b. Birds
   c. Angiosperms d. Fungi
10. Which of the following is a crustacean?
   a. Prawn b. Snail
   c. Sea anemone d. Hydra
11. The respiratory pigment in cockroach is
   a. Haemoglobin b. Haemocyanin
   c. Oxyhaemoglobin d. Haemoerythrin
12. Exoskeleton of which phylum consists of chitinous cuticle?
   a. Annelida b. porifera
   c. Arthropoda d. Echinodermata
13. Lateral line sense organs occur in
   a. Salamander b. Frog
   c. Water snake d. Fish
14. The limbless amphibian is
   a. Icthyophis b. Hyla
   c. Rana d. Salamander
15. Four chambered heart is present in
   a. Lizard b. Snake
   c. Scorpion d. Crocodile
16. Which of the following is not correctly paired?
   a. Humans – Ureotelic
   b. Birds – Uricotelic
   c. Lizards – Uricotelic
   d. Whale – Ammonotelic
17. Which of the following is an egg laying mammal?
   a. *Delphinus* b. *Macropus*
   c. *Ornithorhynchus* d. *Equus*
18. Pneumatic bones are seen in
   a. Mammalia b. Aves
   c. Reptilia d. Sponges
19. Match the following columns and select the correct option.

Column – I	Column – II
(p) Pila	(i) Devil fish
(q) Dentalium	(ii) Chiton
(r) Chaetopleura	(iii) Apple snail
(s) Octopus	(iv) Tusk shell

   a. p – (ii), q – (i), r – (iii), s – (iv)
   b. p – (iii), q – (iv), r – (ii), s – (i)
   c. p – (ii), q – (iv), r – (i), s – (iii)
   d. p – (i), q – (ii), r – (iii), s – (iv)
20. In which of the following phyla, the adult shows radial symmetry but the larva shows bilateral symmetry?
   a. Mollusca b. Echinodermata
   c. Arthropoda d. Annelida
21. Which of the following is correctly matched?
   a. Physalia – Portugese man of war
   b. Pennatula – Sea fan
   c. Adamsia – Sea pen
   d. Gorgonia – Sea anemone
22. Why are spongin and spicules important to a sponge?
23. What are the four characteristics common to most animals?

24. List the features that all vertebrates show at some point in their development.
25. Compare closed and opened circulatory system
26. Compare Schizocoelom with enterocoelom
27. Identify the structure that the archenteron becomes in a developing animal.
28. Observe the animal below and answer the following questions

    a. Identify the animal
    b. What type of symmetry does this animal exhibit?
    c. Is this animal Cephalized?
    d. How many germ layers does this animal have?
    e. How many openings does this animal's digestive system have?
    f. Does this animal have neurons?
29. Choose the term that does not belong in the following group and explain why it does not belong?

    Notochord, cephalisation, dorsal nerve cord and radial symmetry
30. Why flatworms are called acoelomates?
31. What are flame cells?
32. Concept Mapping - Use the following terms to create a concept map that shows the major characteristic features of the phylum nematoda:

    Round worms, pseudocoelomates, digestive tract, cuticle, parasite, sexual dimorphism
33. In which phyla is the larva trochopore found?
34. Which of the chordate characteristics do tunicates retain as adults?
35. List the characteristic features that distinguish cartilaginous fishes with living jawless fishes
36. List three features that characterise bony fishes.
37. List the functions of air bladder in fishes.
38. Write the characteristics that contributes to the success of reptiles on land.
39. List the unique features of bird's endoskeleton.
40. Could the number of eggs or young ones produced by an oviparous and viviparous female be equal? Why?

References

1. Jordan E. L. and Verma P.S. (2001) Invertebrate Zoology Revised Edition, Published by S. Chand Publications.
2. Darrell S. V and R Moore (2004) Biology: Laboratory Manual 7th Edition. McGraw-Hill College.
3. Kotpal R.L. (2014) Modern Text Book of Zoology: Vertebrates. Rastogi Publications.
4. Kotpal R.L. (2014) Modern text book of zoology : Invertebrates : animal diversity- I. 11th Edition. Meerut : Rastogi Publications.

UNIT II **Chapter 3**

Tissue Level of Organisation

Chapter Outline

A reflective layer of tissue called tapetum lucidum, enhances night time vision in most of the animals like cat.

Learning Objectives:

- *Recognises the types of tissues based on their characteristic features*
- *Understands the description, location, functions and modification of tissues.*
- *Understands the significance of muscles, connective and neural tissues.*

69G7TP

In multicellular organisms, cells do not operate independently, instead, they form tight cell communities that live and work together. Individual body cells are specialized, with each type performing specific functions that helps to maintain homeostasis and benefits the body as a whole. Cell specialization is obvious. How the muscle cell looks and acts differs greatly from skin cells. Cell specialization allows the body to function in co-ordinated ways.

Groups of cells that are similar in structure and perform common or related functions are called '**tissues**'.

Tissues are organized in specific proportions and patterns to form **organs** like lungs, heart, stomach, kidneys, ovaries, testes etc; hence the tissues are called the '**living fabrics**'. If two or more organs perform common physical and chemical functions they are called '**organ systems**', Eg: digestive system, respiratory system, circulatory system, excretory system, etc. Most organs contain different types of tissues and their arrangement determines the organ's structure and functions. The study of tissues, or **histology**, complements the study of gross anatomy. Together they provide the structural basis for understanding organ physiology.

3.1. Animal Tissues

Animal tissues are classified according to the size, shape and function of the cells. There

Classification of Animal Tissues

- Epithelial
  - Simple
    1. Squamous
    2. Cuboidal
    3. Columnar
    4. Ciliated
    5. Pseudostratified
  - Compound
    - Stratified
      - Squamous
        1. Keratinized
        2. Non-Keratinized
      - Cuboidal
      - Columnar
    - Transitional
- Connective
- Muscular
- Neural

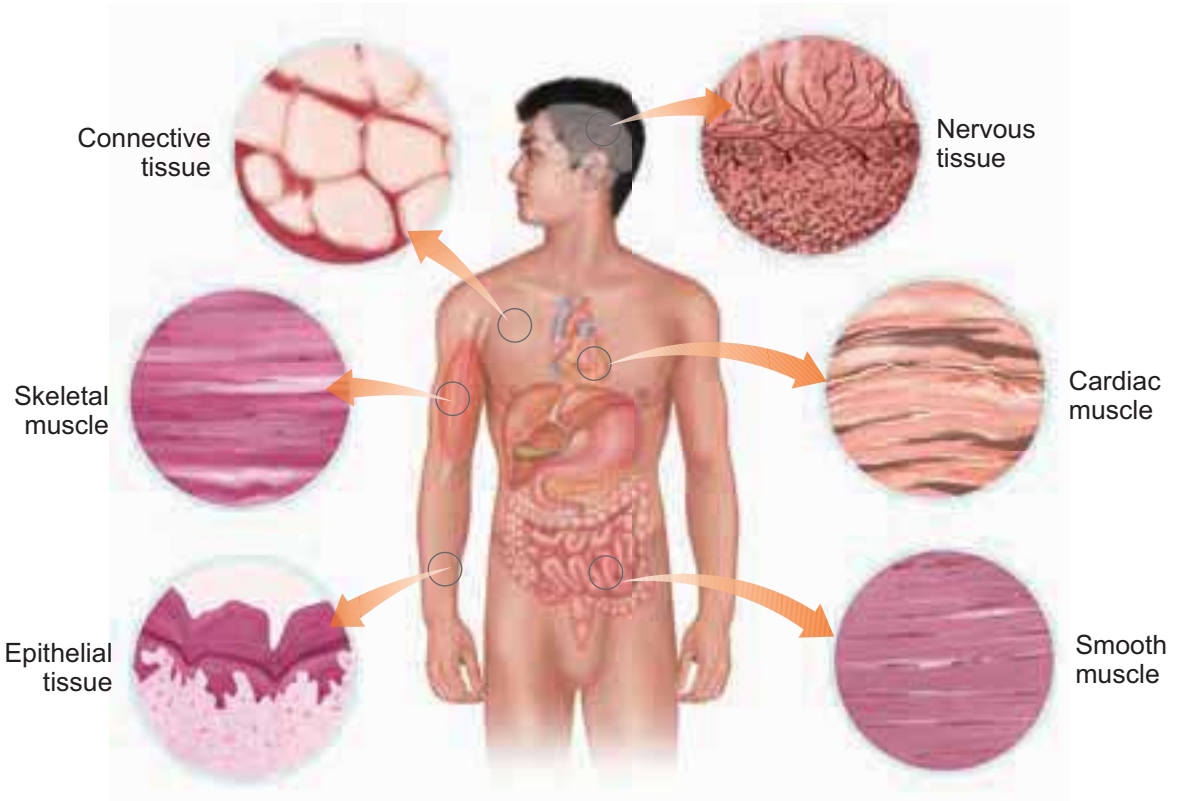


Figure 3.1 Types of Tissues in Human

are four primary (basic) tissue types that interweave to form the 'fabric' of the body. They are, the epithelial tissue (covering), the connective tissue (support), the muscle tissue (movement) and the nervous tissue (control) (Figure 3.1).

3.2 Epithelial Tissue

Epithelial tissue is a sheet of cells that covers the body surface or lines the body cavity. It occurs in the body as a **covering, as a lining epithelium and as glandular, epithelium**. The functions of epithelium includes **protection, absorption, filtration, excretion, secretion** and **sensory reception.** Based on the structural modification of the cells, the epithelial tissues are classified into simple epithelium and compound epithelium or stratified epithelium.

Simple epithelium is composed of a single layer of cells. They are found in the organs of absorption, secretion and filtration. Simple epithelial tissue is further classified into squamous epithelium, cuboidal epithelium, columnar epithelium, ciliated epithelium and pseudostratified epithelium (Figure 3.2). The **squamous epithelium** is made of a single thin layer of flattened cells with irregular boundaries. They are found in the kidney glomeruli, air sacs of lungs, lining of heart, blood vessels and lymphatic vessels and are involved in functions like forming a diffusion boundary and filtration in sites where protection is not important. The **cuboidal epithelium** is made of a single layer of cube like cells. This tissue is commonly found in the kidney tubules, ducts and secretory portions of small glands

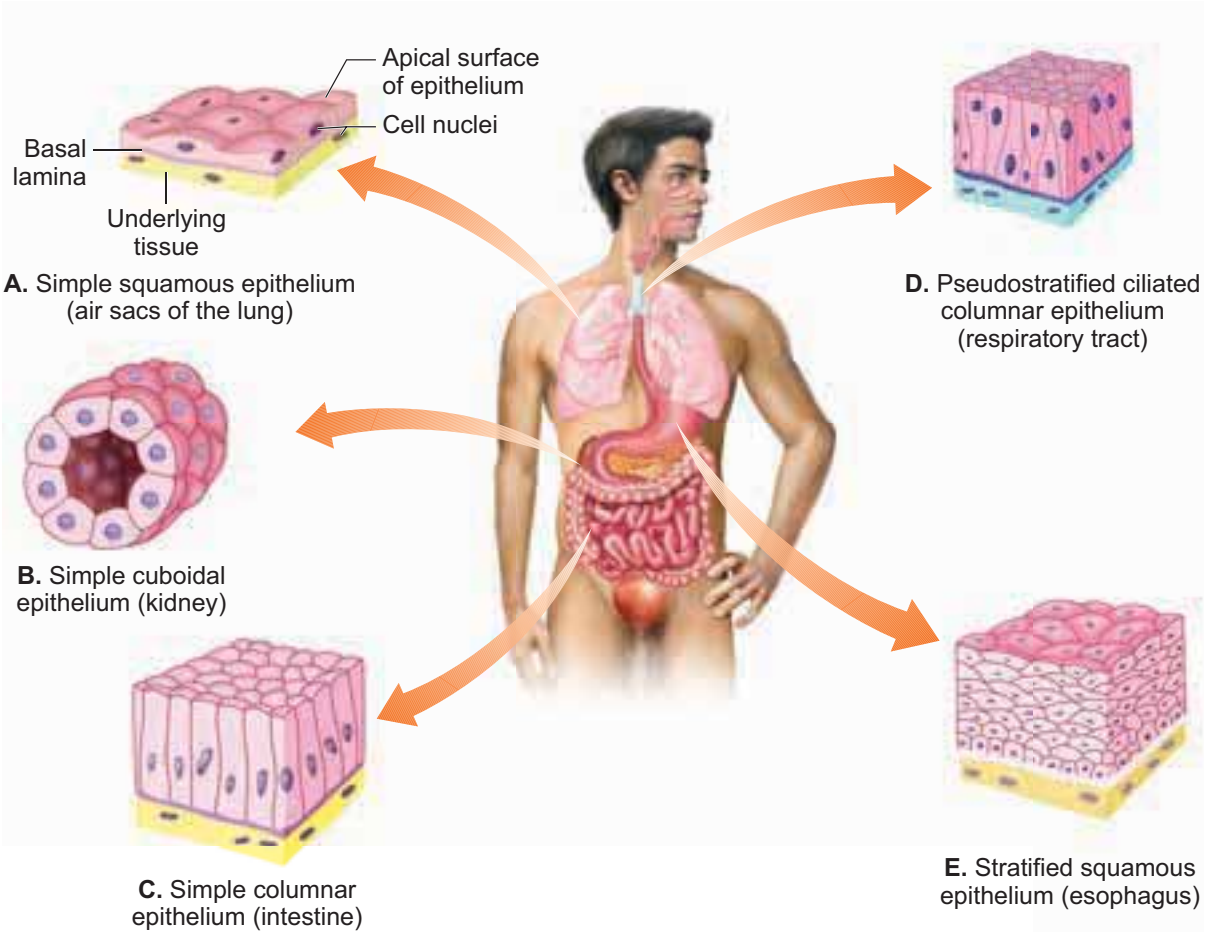


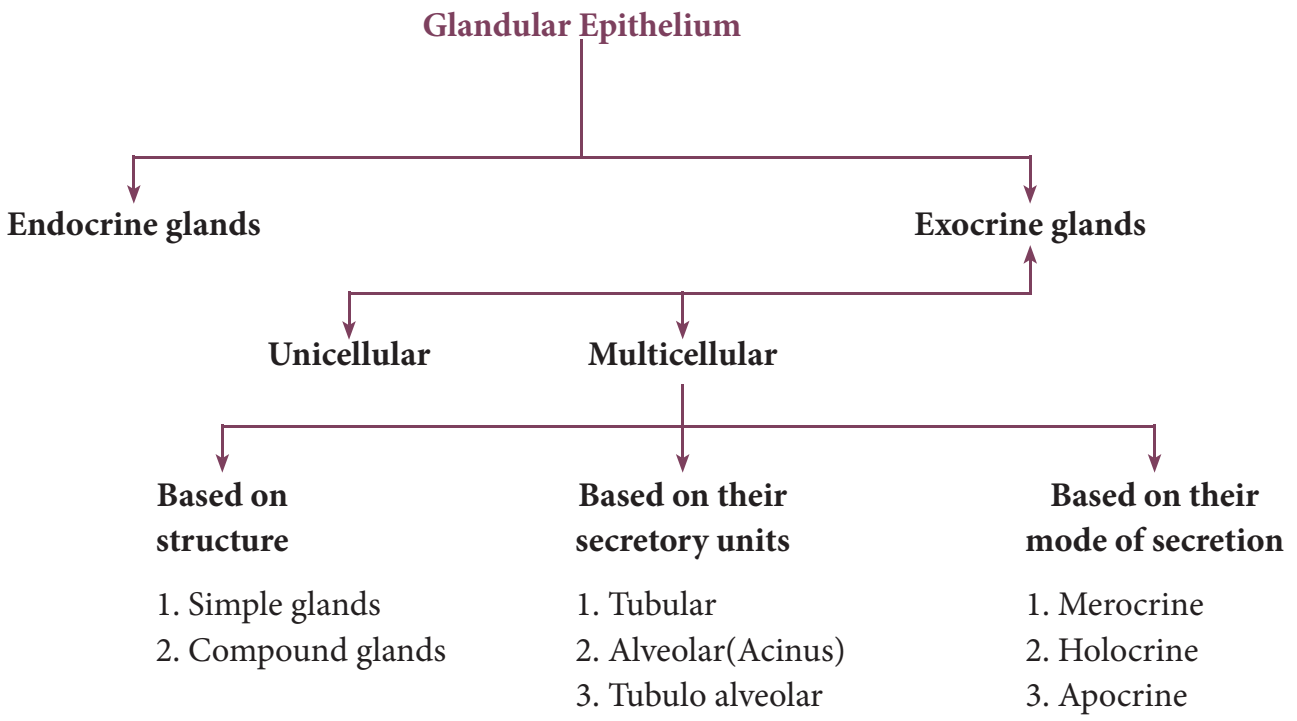
Figure 3.2 Types of Epithelial tissues

and surface of the ovary. Its main functions are secretion and absorption. The **columnar epithelium** is composed of single layer of tall cells with round to oval nuclei at the base. It lines the digestive tract from the stomach to the rectum. The two modifications of this lining are the presence of **microvilli** on the apical surface of the absorptive cells and **Goblet cell** which secretes the protective lubricating mucus. The functions of this epithelium include absorption, secretion of mucus, enzymes and other substances. If the columnar cells bear cilia on their free surfaces they are called ciliated epithelium. This **ciliated type** propels mucus by ciliary actions and it lines the small bronchioles, fallopian tubes and uterus. **Nonciliated type** lines most of the digestive tract, gall bladder and secretory ducts of glands.

Pseudo-stratified epithelial cells are columnar, but unequal in size. Although the epithelium is single layered yet it appears to be multi-layered because the nuclei lie at different levels in different cells. Hence, it is also called pseudostratified epithelium and its functions are protection, secretion and absorption. Ciliated forms line the trachea and the upper respiratory tract. The non ciliated forms, line the epididymis, large ducts of a glands and tracts of male urethra

Important epithelial tissue disorders:
Eczema, Psoriasis, Epithelial carcinoma and severe asthma

Some of the cuboidal or columnar cells get specialized for secretion and are called **glandular epithelium** (Figure 3.3). They are mainly of two types: unicellular, consisting of isolated glandular cells (goblet cells of the **alimentary canal**), and multicellular, consisting of cluster of cells (**salivary gland**). On the basis of the mode of pouring of their secretions, glands are divided into two categories namely exocrine and endocrine glands. **Exocrine glands** secrete mucus, saliva, earwax, oil, milk, digestive enzymes and other cell products. These products are released



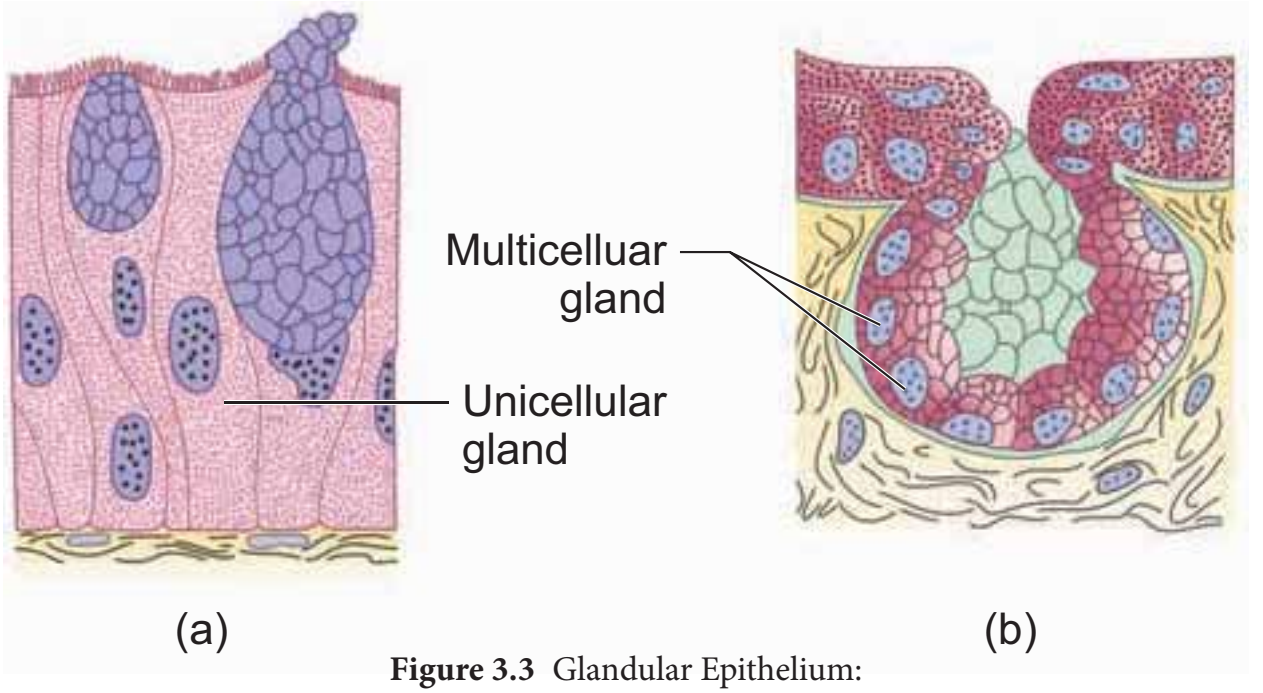


Figure 3.3 Glandular Epithelium:

through ducts or tubes. In contrast endocrine glands do not have ducts. Their secretions called hormones are secreted directly into the fluid bathing the gland. The exocrine glands are classified as unicellular and multicelluar glands. The multicelluar glands are further classified based on the structure as **simple** and **compound glands,** based on their secretory units as **tubular, alveolar (Acinus)** and **tubulo alveolar**. Based on the mode of secretion exocrine glands are classified as **merocrine, holocrine** and **apocrine**.

Compound epithelium is made of more than one layer (multi-layered) of cells and thus has a limited role in secretion and absorption(Figure 3.4). The compound epithelia may be stratified and transitional.

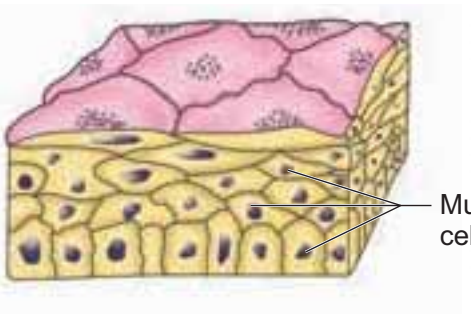


Figure 3.4 Compound Epithelium

Their main function is to provide protection against chemical and mechanical stresses. They cover the dry surface of the skin, the moist surface of buccal cavity, pharynx, inner lining of ducts of salivary glands and of pancreatic ducts. There are four types of compound epithelium namely, stratified squamous epithelium, cuboidal epithelium, columnar epithelium and transitional epithelium. **Stratified squamous epithelium** is of two types called **keratinized type** which forms the dry epidermis of the skin and the **non keratinized type** forms the moist lining of the oesophagus, mouth, conjunctiva of the eyes and vagina. **Stratified cuboidal epithelium** mostly found in the ducts of sweat glands and mammary glands. **Stratified columnar epithelium** has limited distribution in the body, found around the lumen of the pharynx, male urethra and lining of some glandular ducts.

Stratified epithelia are "built" for protection or to resist abrasion. What are the simple epithelia better at?

Transitional Epithelium is found lining the ureters, urinary bladder and part of the urethra. This epithelium allows stretching and is protective in function.

All cells of the epithelium are held together with little intercellular material. In most of the animal tissues, specialized junctions provide both structural and functional links between its individual cells. Three types of cell junctions are found in the epithelium and other tissues. These are called as tight, adhering and gap junctions. **Tight junctions** help to stop substances from leaking across a tissue. **Adhering junctions** perform cementing to keep neighbouring cells together. **Gap junctions** facilitate the cells to communicate with each other by connecting the cytoplasm of adjoining cells, for rapid transfer of ions, small molecules and sometimes big molecules.

3.3 Connective Tissue

Connective tissue develops from the **mesoderm** and is widely distributed in the body. There are four main classes of connective tissues. They are **connective tissue** (which includes fat and the fibrous tissue of ligaments), **cartilage, bones** and **blood.** Major functions of connective tissues are **binding** and **support**, **protection**, **insulation** and **transportation** of substances.

69Q3VC

1. What type of connective tissue is damaged when one get cut on his index finger accidently?
2. The stored lipids are in the form of adipose tissue. Are they coloured? why?

Components of connective tissue

All connective tissues consist of three main components namely fibres, ground substance and cells. The **'Fibres'** of connective tissue provide support. Three types of fibres are found in the connective tissue matrix. They are **collagen**, **elastic** and **reticular** fibres. Connective tissue are of two types namely, **Loose connective tissues** (Areolar, Adipose and Reticular) and **Dense connective tissues** (dense regular, dense irregular and elastic). **Specialized connective tissues** include cartilage, bone and blood.

Loose connective tissues

In this tissue the cells and fibres are loosely arranged in a semi fluid ground substances. For example the **Areolar connective tissue** beneath the skin acts as a support framework for epithelium and acts as a reservoir of water and salts for the surrounding body tissues, hence aptly called ***tissue fluid.*** It contains fibroblasts, macrophages, and mast cells (Figure 3.5).

Connective Tissues

Loose Connective Tissues	Dense Connective Tissues	Specialised Connective Tissues
1. Areolar Tissue	1. Dense Regular	1. Cartilage
2. Adipose Tissue	2. Dense Irregular	2. Bone
3. Reticular Tissue	3. Elastic	3. Blood

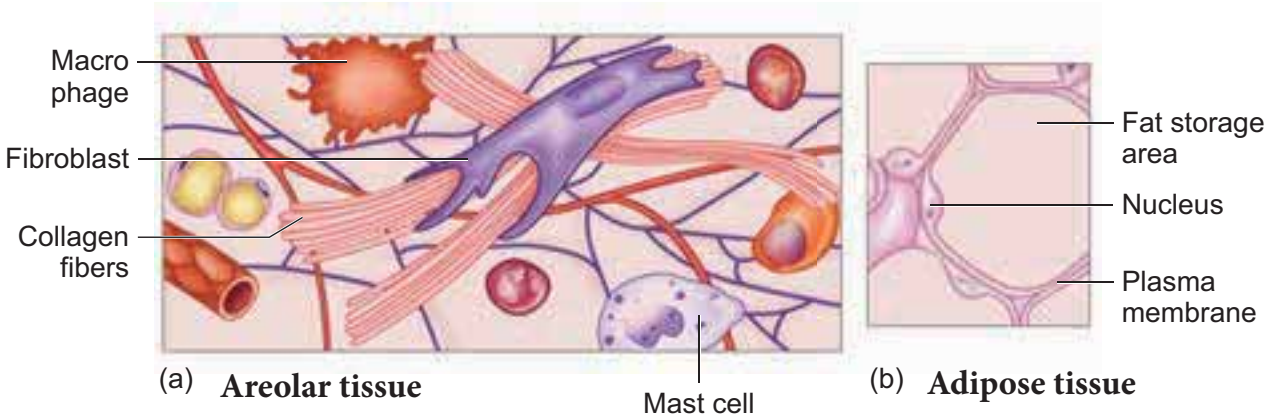


Figure 3.5 Loose connective tissues:

Adipose tissue is similar to areolar tissue in structure and function and located beneath the skin. Adipocytes commonly called **adipose** or **fat cells** predominate and account for 90% of this tissue mass. The cells of this tissue store fats and the excess nutrients which are not utilised immediately are converted to fats and are stored in tissues. Adipose tissue is richly vascularised indicating its high metabolic activity. While fasting, these cells maintain life by producing and supplying energy as fuel. Adipose tissues are also found in subcutaneous tissue, surrounding the kidneys, eyeball, heart, etc. Adipose tissue is called '**white fat**' or **white adipose tissue.** The adipose tissue which contains abundant mitochondria is called '**Brown fat**' or **Brown adipose tissue.** White fat stores nutrients whereas brown fat is used to heat the blood stream to warm the body. Brown fat produces heat by **non-shivering thermogenesis** in neonates.

Reticular connective tissue resembles areolar connective tissue, but, the matrix is filled with fibroblasts called reticular cells. It forms an internal framework (**stroma**) that supports the blood cells (largely lymphocytes) in the lymph nodes, spleen and bone marrow.

Dense connective tissues (connective tissue proper)

Fibres and fibroblasts are compactly packed in the dense connective tissues. Orientation of fibres show a regular or irregular pattern and is called dense regular and dense irregular tissues. **Dense regular connective tissues** primarily contain collagen fibres in rows between many parallel bundles of tissues and a few elastic fibres. The major cell type is **fibroblast.** It attaches muscles and bones and withstands great tensile stress when pulling force is applied in one direction. This connective tissue is present in **tendons,** that attach skeletal muscles to bones and ligaments attach one bone to another. **Dense irregular connective tissues** have bundles of thick collagen fibres and fibroblasts which are arranged irregularly. The major cell type is the **fibroblast**. It is able to withstand tension exerted in many directions and provides structural strength. Some elastic fibres are also present. It is found in the skin as the leathery dermis and forms fibrous capsules of organs such as kidneys, bones, cartilages, muscles, nerves and joints. **Elastic connective**

tissue contains high proportion of elastic fibres. It allows recoil of tissues following stretching. It maintains the pulsatile flow of blood through the arteries and the passive recoil of lungs following inspiration. It is found in the walls of large arteries; ligaments associated with **vertebral column** and within the walls of the **bronchial tubes.**

Specialised connective tissues are classified as cartilage, bones and blood. The intercellular material of **cartilage** is solid and pliable and resists compression. Cells of this tissue (chondrocytes) are enclosed in small cavities within the matrix secreted by them (Figure 3.6). Most of the cartilages in vertebrate embryos are replaced by bones in adults. Cartilage is present in the tip of nose, outer ear joints, ear pinna, between adjacent bones of the vertebral column, limbs and hands in adults.

Bones have a hard and non-pliable ground substance rich in calcium salts

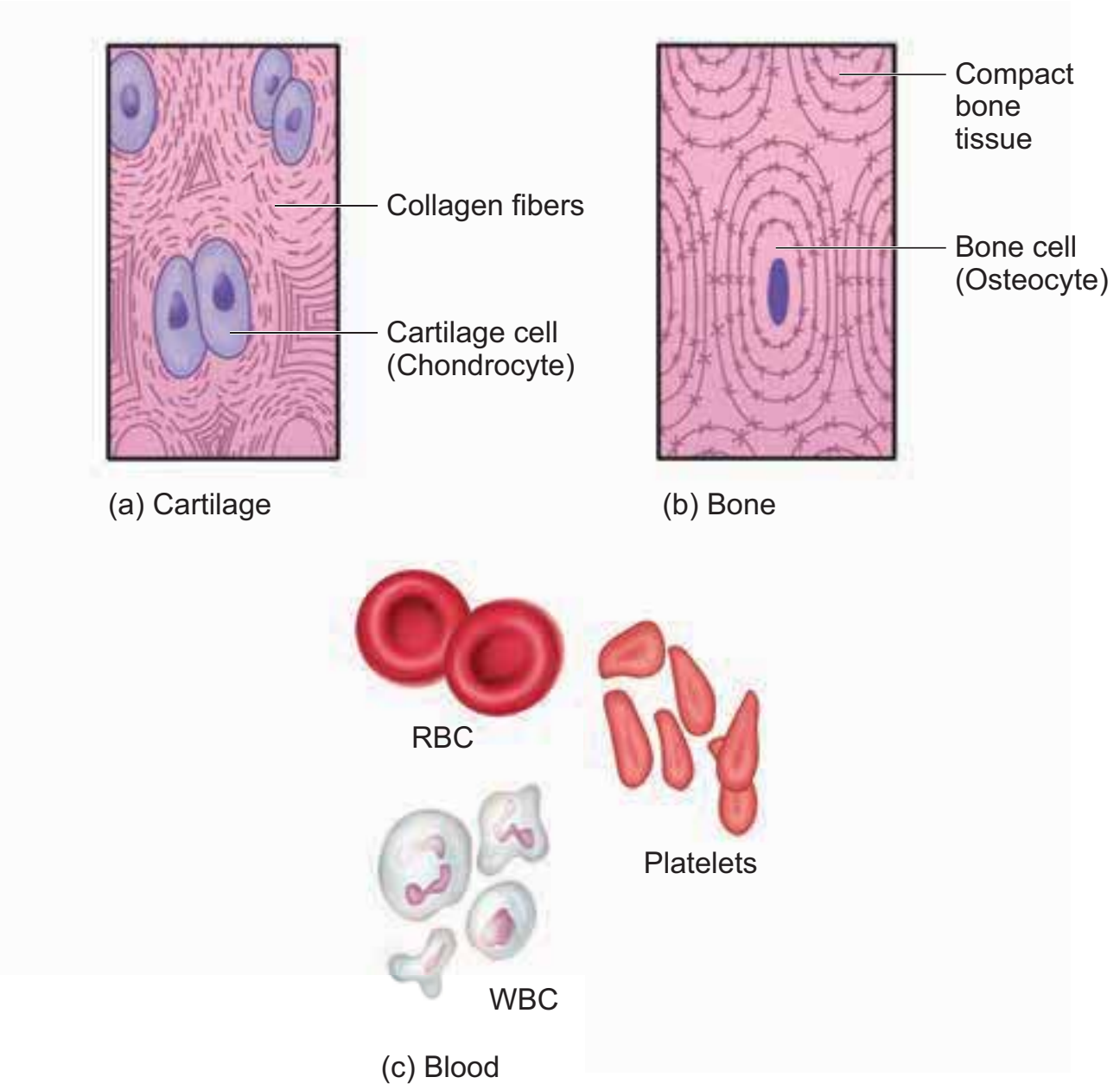
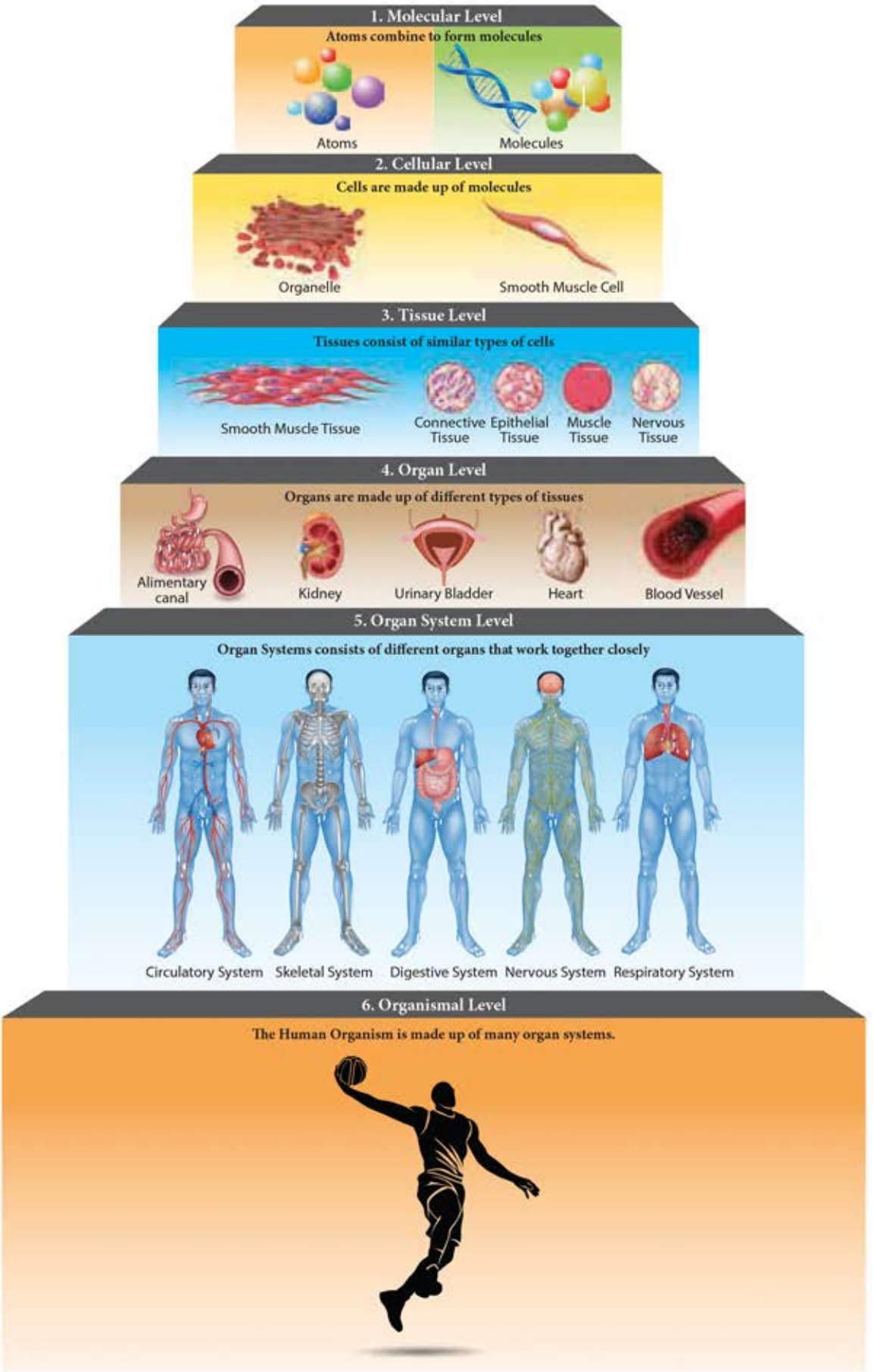


Figure 3.6 Specialized connective tissues

Levels of Structural Organisation



and collagen fibres which gives strength to the bones. It is the main tissue that provides structural frame to the body. Bones support and protect softer tissues and organs. The bone cells (osteocytes) are present in the spaces called lacunae. Limb bones, such as the long bones of the legs, serve weight-bearing functions. They also interact with skeletal muscles attached to them to bring about movements. The bone marrow in some bones is the site of production of blood cells.

Blood is the fluid connective tissue containing plasma, red blood cells (RBC), white blood cells (WBC) and platelets. It functions as the transport medium for the cardiovascular system, carrying nutrients, wastes, respiratory gases throughout the body. You will learn more about blood in Chapter 7.

Important connective tissue disorders: (Heritable types)

1. **Ehler's -Danlos syndrome** – Defect in the synthesis of collagen in the joints, heart valves, organ walls and arterial walls.
2. **Stickler syndrome** – Affects collagen and results in facial abnormalities.
3. **Rhabdomyosarcoma** – Life threatening soft tissue tumour of head, neck and urinogenital tract.

Autoimmune connective tissue disorders

1. **Rheumatoid arthritis:** The immune cells attack and inflame the membranes around the joints. It can also affect heart, lungs and eyes.
2. **Sjogren's syndrome:** Progressive inability to secrete saliva and tears.

Biopsy is an examination of tissue or liquid removed from a living body to discover the presence, cause or extent of a disease.

Autopsy is a post-mortem (dissection of a dead body) examination to discover the cause of death or the extent of disease.

The field of **Forensic science** effectively uses the histological techniques to trace out crimes.

3.4 Muscle Tissue

Each muscle is made of many long, cylindrical fibres arranged in parallel arrays. These fibres are composed of numerous fine fibrils, called myofibrils. Muscle fibres contract (shorten) in response to stimulation, then relax (lengthen) and return to their uncontracted state in a coordinated fashion. In general muscles play an active role in all the movements of the body.

Muscles are of three types, skeletal, smooth and cardiac. **Skeletal muscle tissue** is closely attached to skeletal bones. In a typical muscle such as the biceps, the striated (striped) skeletal muscle fibres are bundled together in a parallel fashion. A sheath of tough connective tissue encloses several bundles of muscle fibres (You will learn more about this in Chapter 9).

The **smooth muscle** fibres taper at both ends (fusiform) and do not show striations (Figure 3.7). Cell junctions hold them together and they are bundled together in a connective tissue sheath. The walls of internal organs such as the blood vessels, stomach and intestine contain this type of muscle

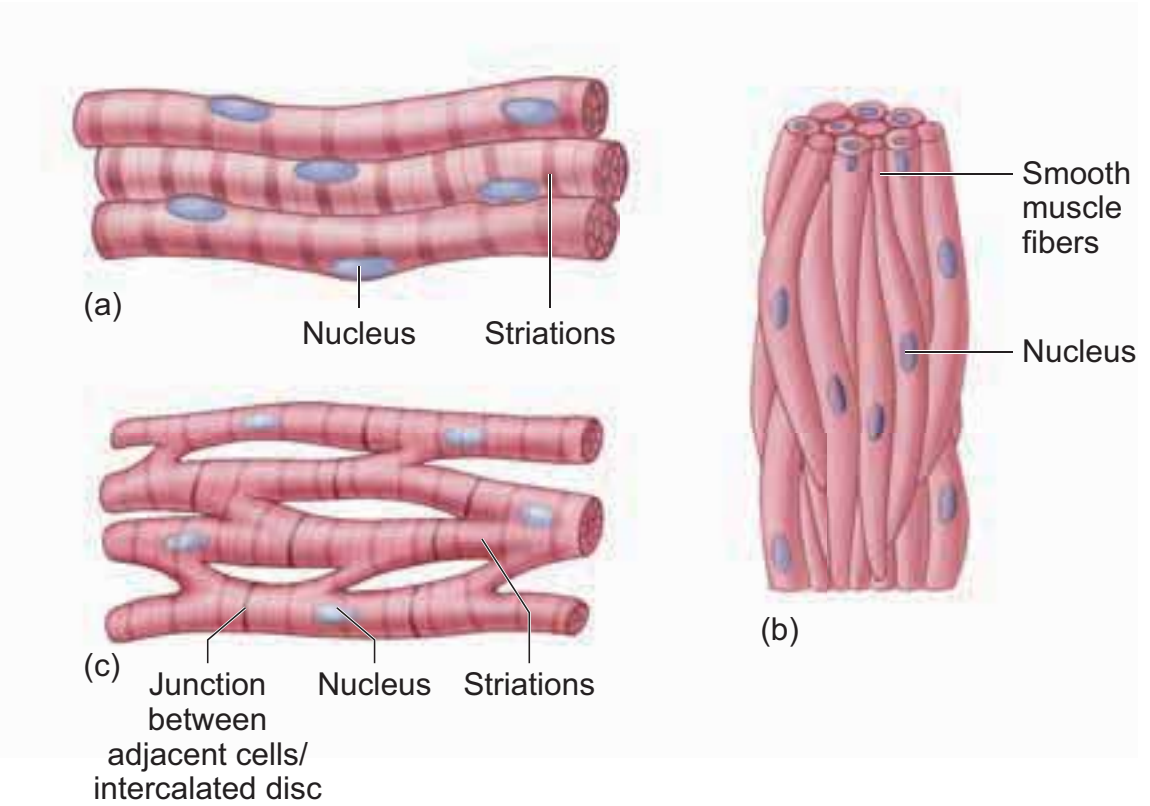


Figure 3.7 Muscle tissues

tissue. Smooth muscles are 'involuntary' as their functions cannot be directly controlled. Unlike the smooth muscles, skeletal muscles cannot be controlled by merely thinking.

Cardiac muscle tissue is a contractile tissue present only in the heart. Cell junctions fuse the plasma membranes of cardiac muscle cells and make them stick together. Communication junctions (intercalated discs) at some fusion points allow the cells to contract as a unit, i.e., when one cell receives a signal to contract, its neighbours are also stimulated to contract.

DO YOU KNOW?

Palmaris muscle:

This long narrow muscle runs from the elbow to the wrist and is important for hanging and climbing in primates, is missing in 11% of humans today.

You are looking at a slide of a tissue through the compound microscope and you see striped branching cells that connect with one another. What type of muscle are you viewing?

Diseases of Nervous System:

1. **Parkinson's disease:** A degenerative disorder of the nervous system that affects movement, often including tremors.
2. **Alzheimer's disease:** It is a chronic neurodegenerative disease which includes the symptoms of difficulty in remembering recent events, problems with language, disorientation and mood swings.

1. A player has sustained a severe injury during football practice and was told that he has a torn knee cartilage. Can he expect a quick uneventful recovery? Explain your response.

2. An overweight high school student, is overheard telling her friend that she is going to research how she can transform some of her white fat to brown fat. What is her rationale here (assuming it is possible)?

3.5 Neural Tissue

Nervous tissue exerts the greatest control over the body's responsiveness to changing conditions. Neurons, the unit of neural system are excitable cells (Figure 3.8). The neuroglial cells which constitute the rest of the neural system protect and support the neurons. Neuroglia makes up more than one-half of the volume of neural tissue in our body.

When a neuron is suitably stimulated, an electrical disturbance is generated which swiftly travels along its plasma membrane. Arrival of the disturbance at the neuron's endings, or output zone, triggers events that may cause stimulation or inhibition of adjacent neurons and other cells (You will study in detail in Chapter 10)

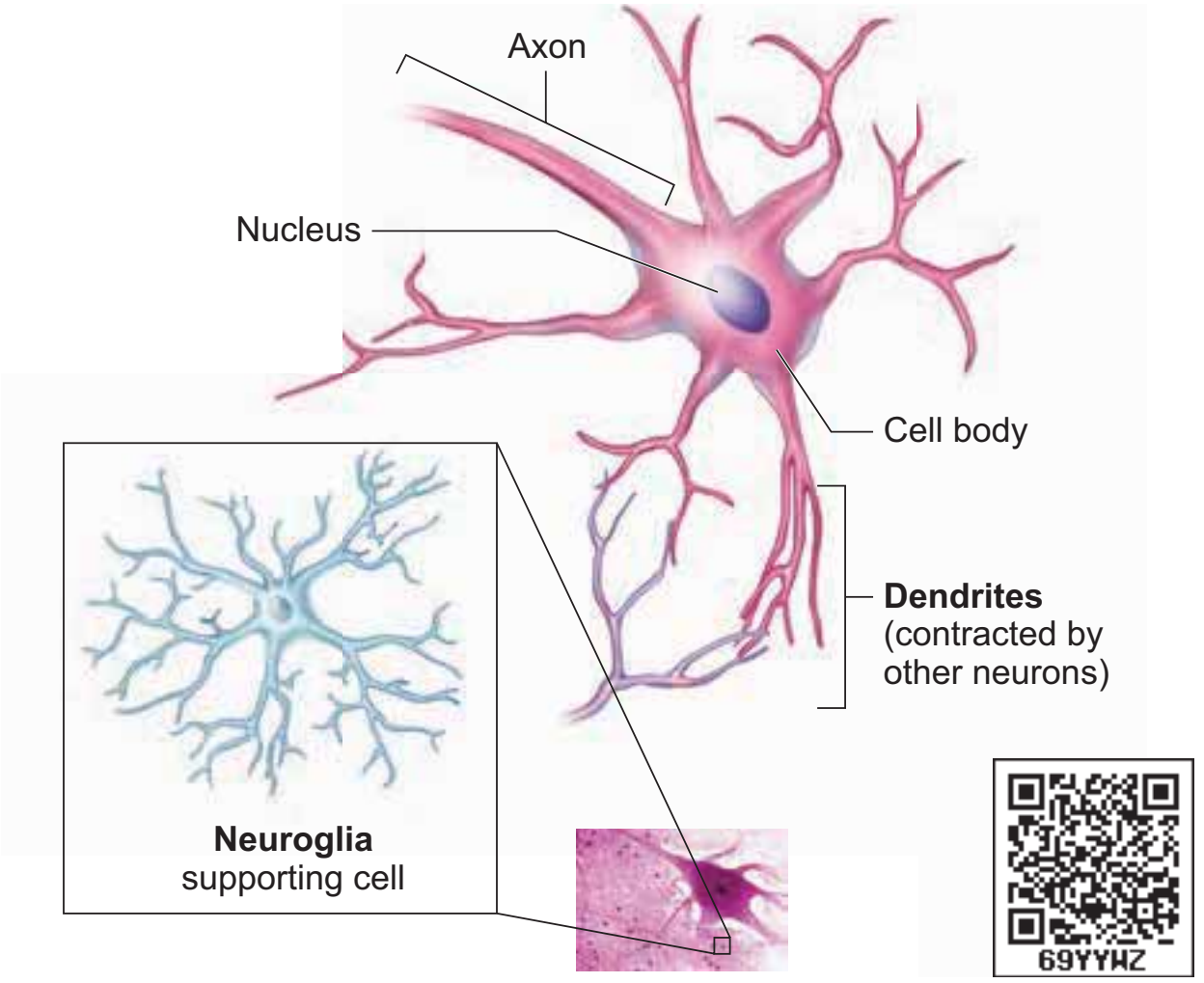
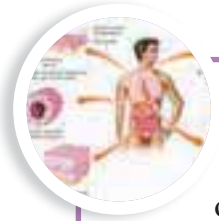


Figure 3.8 Nervous tissues with neuroglia

ICT Corner

The Online Epithelium



Let's explore the anatomy and functions of **Epithelium Tissues**.

Step – 1

Use the URL to open 'The Online Epithelium'page. Click any of the organ given in the list to view the interactive epithelial tissues present in that organ.

Step – 2

Click the play icon to load the 3D interactive. The loaded 3DTissue can be viewed 360 degree by click and drag of the mouse.

Step – 3

Roll the mouse over the interactive diagram and click the number on the diagram. A brief description of the parts will appear, description can be viewed by selecting the parts given at the bottom of the activity window.

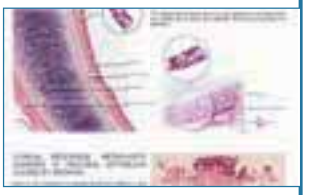
Step – 4

Additional information regarding the particular epithelial tissue can be learned from the descriptions given below the 3D interactive diagram.

Step 1

Step 2

Step 3



Step 4

The Online Epithelium'sURL:

http://www.epithelium3d.com/index.html

B167_STD_11_ZOOLOGY_EM

* Pictures are indicative only

Activity

1. Students are asked to identify the unlabelled slides of tissues and to classify them. Similar exercise can also be accomplished by projecting unlabelled histological images on a screen. They can identify the slides of different tissues through microscope
2. The preparation of smear of stratified squamous epithelia from the inner lining of cheek allows the students to make their own slides using biological stain. They will have the experience of examining their cheek cells.

Summary

The body cells combine to form four different types of tissues; **Epithelial, Connective, Muscle and Nervous tissues.** Though the cells of these tissues share certain features in common, by no means they are identical. They belong together because they have basic fundamental resemblances. The important concept to carry away with you is that tissues, despite their unique abilities, cooperate to keep the body safe, healthy, viable and whole.

Glossary

Acinus – Cells arranged into a circular secretory unit

Adipocyte – Large cell (up to 200 microns) with only a thin film of cytoplasm due to the presence of a large fat droplet.

Adipose tissue – A group of adipocytes.

Bone – Specialized connective tissue with a mineralized (hydroxyapatite) matrix.

Collagen – A triple helix protein which allows for great tensile strength.

Goblet cell – special mucus secreting columnar epithelial cell located in the respiratory tract and intestine.

Lacunae – A cavity or depression especially in the bone

Mast cells – Cells filled with basophilic granules found in numbers in connective tissue and releases histamine and other substances during inflammatory and allergic reactions.

Macrophages – Immune cells derived from monocytes; engaged in phagocytosis of microbes and debris.

Evaluation

1. The main function of the cuboidal epithelium is
   a. Protection b. Secretion
   c. Absorption d. Both (b) and (c)
2. The ciliated epithelium lines the
   a. Skin b. Digestive tract
   c. Gall bladder d. Trachea
3. What type of fibres are found in connective tissue matrix?
   a. Collagen b. Areolar
   c. Cartilage d. Tubular

4. Prevention of substances from leaking across the tissue is provided by
   a. Tight junction
   b. Adhering junction
   c. Gap junction
   d. Elastic junction
5. Non-shivering thermogenesis in neonates produces heat through
   a. White fat b. Brown fat
   c. Yellow fat d. Colourless fat
6. Some epithelia are pseudostratified. What does this mean?
7. Differentiate white adipose tissue from brown adipose tissue.
8. Why blood is considered as a typical connective tissue?
9. Differentiate between elastic fibres and elastic connective tissue.
10. Name any four important functions of epithelial tissue and provide at least one example of a tissue that exemplifies each function.
11. Write the classification of connective tissue and their functions
12. What is an epithelium? Enumerate the characteristic features of different epithelia.

Reference

1. Guyton and Hall, 2003 Text book of Medical physiology, Harcourt Indian Pvt. Ltd.,
2. Marieb E. and Hoehn K. , 2010 ,Human Anatomy & Physiology. Eighth Edition. Pearson Education Inc.
3. Silventhorn D-U, 2016, Human physilology, Seventh Edition, Pearson Benjamin cummings publishing Ltd.,

UNIT II

Chapter 4

Organ and Organ Systems in Animals

A function to each organ and each organ to its own function is seen in all animals.

Chapter Outline

Learning Objectives:

- *Understands and appreciates the morphology of the earthworm, cockroach and frog.*
- *Recognises the functions of different organ systems.*
- *Appreciates the differences in the structural organization of the earthworm, cockroach frog and Pigeon*

6A8UYM

Introduction

From microbes to the blue whale, organisms occur in different sizes and shapes with a well organized organ and organ systems. The basic tissues (chapter-3) organize to form an organ which in turn associates to form organ systems in multicellular organisms. Such an organization is essential for efficient and better coordinated activities of millions of cells constituting an organism. You are being introduced to understand the morphology and anatomy of three organisms placed at different evolutionary levels to show their organization and functions. Morphology refers to the study of form or externally visible features. The word anatomy is used for the study of internal organs in the animals. This chapter deals with the morphology and anatomy of invertebrates represented by the earthworm and cockroach and the vertebrates represented by the frog and pigeon.

4.1 Earthworm - *Lampito mauritii*

Earthworm is a terrestrial invertebrate that inhabits the upper layers of the moist soil, rich in decaying organic matter. It is nocturnal and during the day it lives in burrows made by burrowing and swallowing the soil. In gardens, they can be traced by their faecal deposits known as worm castings on the soil surface. Earthworms are considered as **"Friends of Farmers".** The common Indian earthworms are *Lampito mauritii* (Syn. *Megascolex mauritii*), *Perioynx excavatus* and *Metaphire posthuma* (Syn.

Pheretima posthuma). Earthworms are also conveniently classified based on their ecological strategies as **epigeics, anecics** and **endogeics** (Figure 4.1). Epigeics (Greek for "up on the earth") are surface dwellers, eg. *Perionyx excavatus* and *Eudrilus eugeniae.* Anecics (Greek for "out of the earth") are found in upper layers of the soil, eg. *Lampito mauritii, Lumbricus terrestris.* Endogeics (Greek for "within the earth") are found in deeper layers of the soil eg. *Octochaetona thurstoni*.

Classification

Phylum	:	Annelida
Class	:	Oligochaeta
Order	:	Haplotaxida
Genus	:	*Lampito*
Species	:	*mauritii*

Morphology

Lampito mauritii is commonly found in Tamil Nadu. It has a long and cylindrical narrow body which is bilaterally symmetrical. *L. mauritii* is 80 to 210 mm in length with a diameter of 3.5 – 5 mm, and is light brown in colour, with purplish tinge at the anterior end. This colour of the earthworm is mainly due to the presence of porphyrin pigment. The body of the earthworm is encircled by a large number of grooves which divides it into a number of compartments called **segments** or **metameres** (Figure 4.2). *L. mauritii* consists of about 165 – 190 segments. The dorsal surface of the body is marked by a dark mid dorsal line (dorsal blood vessel) along the longitudinal axis of the body. The ventral surface is distinguished by the presence of genital openings. The mouth is found in the centre of the first segment

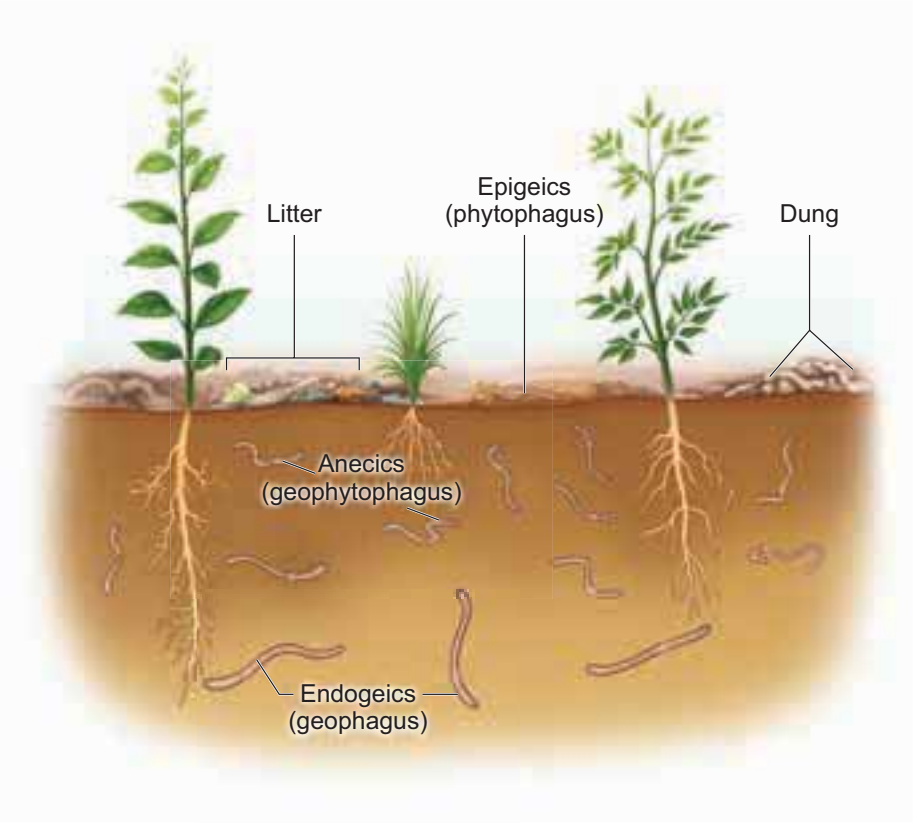


Figure 4.1 Earthworm classification based on ecological strategies

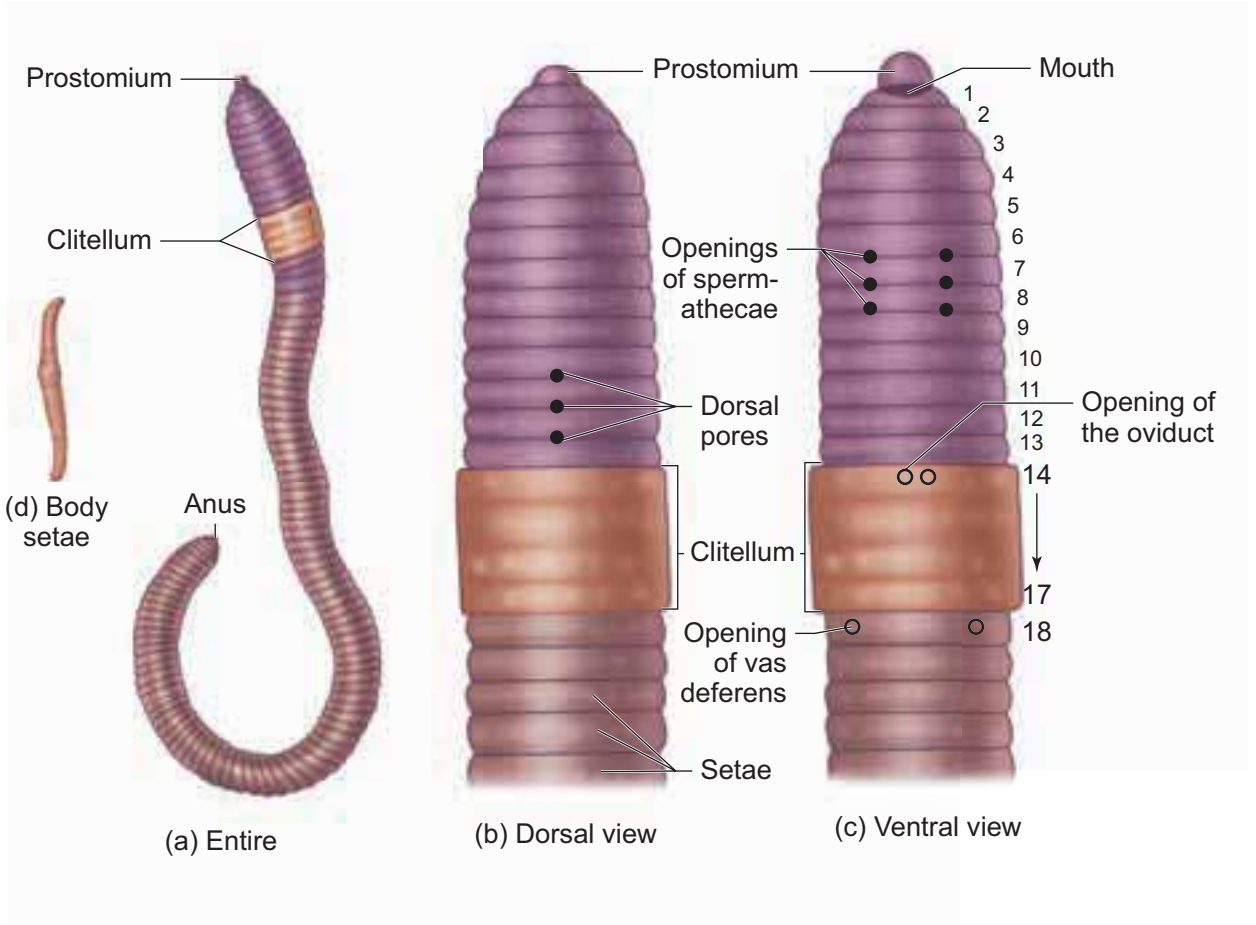


Figure 4.2 *Lampito mauritii*

of the body, called the **peristomium**. Overhanging the mouth is a small flap called the upper lip or **prostomium**. The last segment has the anus called the **pygidium.** In mature worms, segments 14 to 17 may be found swollen with a glandular thickening of the skin called the **clitellum**. This helps in the formation of the cocoon. Due to the presence of clitellum, the body of an earthworm is divided into pre clitellar region (1st – 13th segments), clitellar region (14th – 17th segments) and the post – clitellar region (after the 17th segment). In all the segments of the body except the first, last and clitellum, there is a ring of chitinous body setae. This body setae arises from a setigerous sac of the skin and it is curved as **S** – shaped. Setae can be protruded or retracted and their principal role is in locomotion.

The external apertures are the mouth, anus, dorsal pores, spermathecal openings, genital openings and nephridiopores. The dorsal pores are present from the 10th segment onwards. The coelomic fluid communicates to the exterior through these pores and keeps the body surface moist and free from harmful microorganisms. Spermathecal openings are three pairs of small ventrolateral apertures lying intersegmentally between the grooves of the segments 6/7, 7/8 and 8/9. The female genital aperture lies on the ventral side in the 14th segment and a pair of male genital apertures are situated latero-ventrally in the 18th segment.

DO YOU KNOW?

Longest species of Earthworm

Microchaetus rappi is an African giant earthworm, can reach a length of 6.7 meter (22 feet). *Drawida nilamburansis* is a south Indian (Kerala) species of earthworm and can reach a maximum length up to 1 meter (3 feet).

Nephridiopores are numerous and found throughout the body of the earthworm except a few anterior segments, through which the metabolic wastes are eliminated.

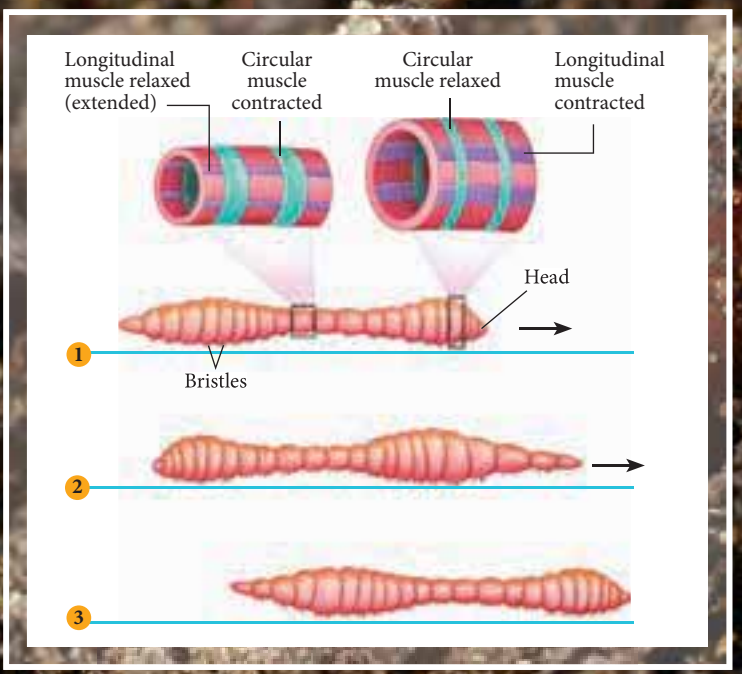
Anatomy

The body wall of the earthworm is very moist, thin, soft, skinny, elastic and consists of the cuticle, epidermis, muscles and coelomic epithelium. The epidermis consists of supporting cells, gland cells, basal cells and sensory cells. A spacious body cavity called the **coelom** is seen between the alimentary canal and the body wall. The coelom contains the coelomic fluid and serves as a **hydrostatic skeleton,** in which the coelomocytes are known to play a major role in regeneration, immunity and wound healing. The coelomic fluid of the earthworm is

Table 4.1: Morphological and anatomical differences between *Lampito mauritii* and *Metaphire posthuma*

S.No	Characters	*Lampito mauritii*	*Metaphire posthuma*
1.	**Shape and size**	Cylindrical 80 mm – 210 mm in length 3.5mm - 5.0 mm in width	Cylindrical 115 – 130 mm in length 5 mm in width
2.	**Colouration**	Light Brown	Dark Brown
3.	**Segmentation**	165 – 190 Segments	About 140 Segments
4.	**Clitellum**	14th – 17th Segments (4)	14th – 16th Segments (3)
5.	**Spermathecal opening**	Three pairs 6/7, 7/8 and 8/9	Four pairs 5/6, 6/7, 7/8 and 8/9
6.	**Pharynx**	3rd – 4th segment	Runs up to 4th Segment
7.	**Oesophagus**	5th segment	8th segment
8.	**Gizzard**	6th segment	8th – 9th segment
9.	**Intestine**	7th segment to anus	15th segment to anus
10.	**Intestinal caeca**	Absent	Present in 26th segment
11.	**Lateral hearts**	8 pairs from 6th to 13th segments	3 pairs from 7th to 9th segments
12.	**Pharyngeal nephridia**	5th - 9th segment	4th – 6th segment
13.	**Micronephridia**	14th to last segment	7th to last segment
14.	**Meganephridia**	19th to last segment	15th to last segment
15.	**Male genital pore**	18th segment	18th segment
16.	**Female genital pore**	14th segment	14th segment

An earthworm uses its hydrostatic skeleton to crawl



The earthworms normally crawl with the help of their body muscles, setae, and buccal chamber. The outer circular and inner longitudinal muscle layers lies below the epidermis of the body wall. The contraction of circular muscles makes the body long and narrow, while that of the longitudinal muscle makes the body short and broad. The locomotion of the earthworm is brought about by the contraction and relaxation of the muscular body wall and is aided by the turgence of the coelomic fluid hence called the Hydrostatic skeleton. The alternate waves of extensions and contractions are aided by the leverage afforded by the buccal chamber and the setae.

milky and alkaline, which consists of granulocytes or eleocytes, amoebocytes, mucocytes and leucocytes.

Digestive system

The digestive system of the earthworm consists of the alimentary canal and the digestive glands. The alimentary canal runs as a straight tube throughout the length of the body from the mouth to anus (Figure 4. 3). The **mouth** opens into the **buccal cavity** which occupies the 1st and 2nd segments. The buccal cavity leads into a thick **muscular pharynx**, which occupies the 3rd and 4th segments and is surrounded by the pharyngeal glands.

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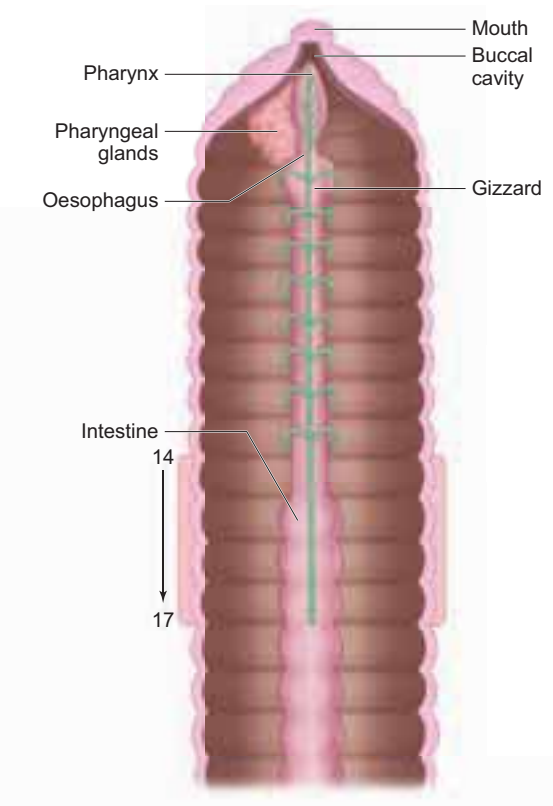

Figure 4.3 *Lampito mauritii* – Digestive System

A small narrow tube, **oesophagus** lies in the 5th segment and continues into a muscular **gizzard** in the 6th segment. The gizzard helps in the grinding of soil particles and decaying leaves. **Intestine** starts from the 7th segment and continues till the last segment. The dorsal wall of the intestine is folded into the cavity as the **typhlosole**. This fold contains blood vessels and increases the absorptive area of the intestine. The inner epithelium consists of columnar cells and glandular cells. The alimentary canal opens to the exterior through the anus.

Intestinal Caeca

In *Metaphire posthuma*, the 26th segment has a pair of short conical out growths called intestinal caecae. It is extended anteriorly up to the 22nd segment. These are digestive glands and secrete an amylolytic enzyme for the digestion of starch. Intestinal caecae are not present in many species of earthworms such as the *Lampito mauritii*.

The ingested organic rich soil passes through the digestive tract where digestive enzymes breakdown complex food into smaller absorbable units. The simpler molecules are absorbed through the intestinal membrane and are utilized. The undigested particles along with earth are passed out through the anus, as **worm castings** or **vermicasts**. The pharyngeal or salivary gland cells and the glandular cells of the intestine are supposed to be the digestive glands which secrete digestive enzymes for digestion of food.

Earthworms have "setae", which are small hair-like bristles, though they are not composed of the same material as human hair. The setae help the earthworm to anchor itself while feeding or mating. It is also found in the wings/exoskeletons of insects. What biological matter forms these structures?

Respiratory System

The earthworm has no special respiratory organs like lungs or gills. Respiration takes place through the body wall. The outer surface of the skin is richly supplied with blood capillaries which aid in the diffusion of gases. Oxygen diffuses through the skin into the blood while carbon dioxide from the blood diffuses out. The skin is kept moist by mucous and coelomic fluid and facilitates exchange of gases.

Circulatory system

Lampito mauritii exhibits a closed type of blood vascular system consisting of blood vessels, capillaries and lateral hearts (Figure 4.4). Two median longitudinal vessels run above and below the alimentary canal as dorsal and ventral vessels of the earthworm. There are paired valves in the dorsal vessels which prevent the backward flow of the blood. The ventral vessel has no valves and is non contractile, allowing the backward flow of blood. In the anterior part of the body the dorsal vessel is connected with the ventral vessel by eight pairs of **commissural vessels** or the **lateral hearts** lying in the 6th to 13th segments. These vessels run on either side of the alimentary canal and pump blood from the dorsal vessel to the ventral

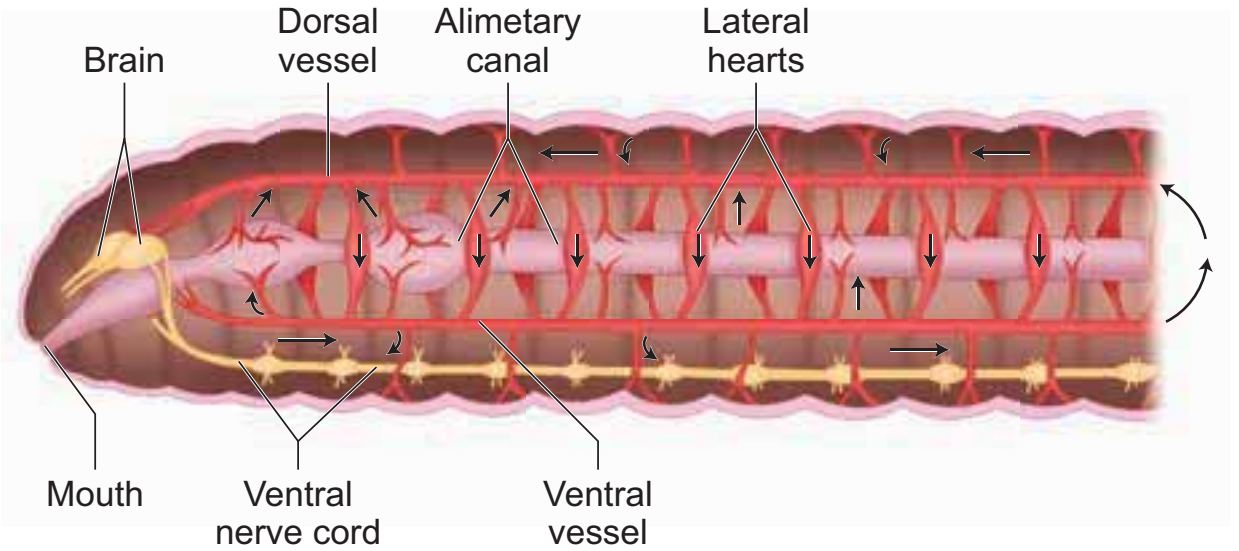

Figure 4.4 *Lampito mauritii*: Circulatory system and Nervous System

vessel. The dorsal vessel receives blood from various organs in the body. The ventral vessel supplies blood to the various organs. Blood glands are present in the anterior segments of the earthworm. They produce blood cells and haemoglobin which is dissolved in the plasma and gives red colour to the blood.

Nervous System

The bilobed mass of nervous tissue called supra - pharyngeal ganglia, lies on the dorsal wall of the pharynx in the 3rd segment, is referred as the "brain". The ganglion found below the pharynx in the 4th segment is called the sub-pharyngeal ganglion (Figure. 4.4). The brain and the sub - pharyngeal ganglia are connected by a pair of circum-pharyngeal connectives. They run one on each side of the pharynx. Thus a nerve ring is formed around the anterior region of the alimentary canal. The double ventral nerve cord runs backward from the sub - pharyngeal ganglion. The brain along with other nerves in the ring integrates sensory inputs and command muscular responses of the body.

The earthworm's receptors are stimulated by a group of slender columnar cells connected with nerves. The **Photoreceptors** (sense of light) are found on the dorsal surface of the body. **Gustatory** (sense of taste) and **olfactory receptors** (sense of smell) are found in the buccal cavity**. Tactile receptors** (sense of touch), **chemoreceptors** (detect chemical changes) and **thermoreceptors** (changes in temperature) are present in the prostomium and the body wall.

How do the earthworm's sense activity in their habitat without eyes, ears or a nose?

Excretory System

Excretion is the process of elimination of metabolic waste products from the body. In earthworm, excretion is effected by segmentally arranged, minute coiled, paired tubules called nephridia. There are three types of nephridia; (i) **pharyngeal** or **tufted nephridia** – present as paired tufts in the 5th - 9th segments (ii) **Micronephridia**

or **Integumentary nephridia** – attached to the lining of the body wall from the14th segment to the last which open on the body surface (iii) **Meganephridia** or **septal nephridia** – present as pair on both sides of intersegmental septa of the 19th segment to the last and open into intestine (Figure 4. 5). The meganephridium has an internal funnel like opening called the nephrostome, which is fully ciliated. The nephrostome is in the preceding segment and the rest of the tube is in the succeeding segment. This tube consists of three distinct divisions, the ciliated, the glandular and the muscular region. The waste material collected through the ciliated funnel is pushed into the muscular part of nephridium by the ciliated region. The glandular part extracts the waste from the blood and finally the wastes exit out through the nephridiopore.

Besides nephridia, special cells on the coelomic wall of the intestine, called chloragogen cells are present. They extract the nitrogenous waste from the blood of the intestinal wall, into the body cavity to be sent out through the nephridia.

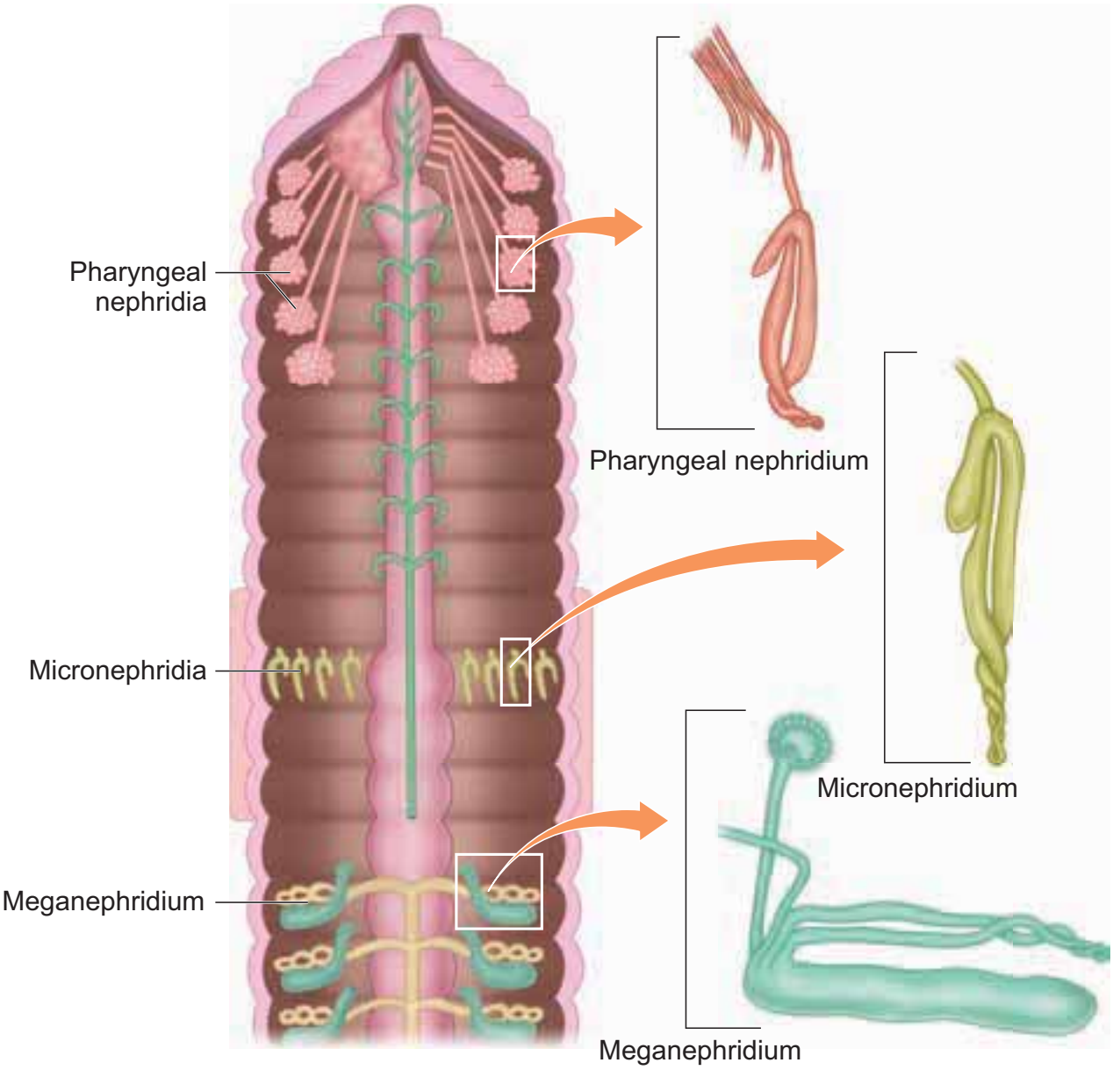

Figure: 4. 5 *Lampito mauritii* – Types of Nephridia

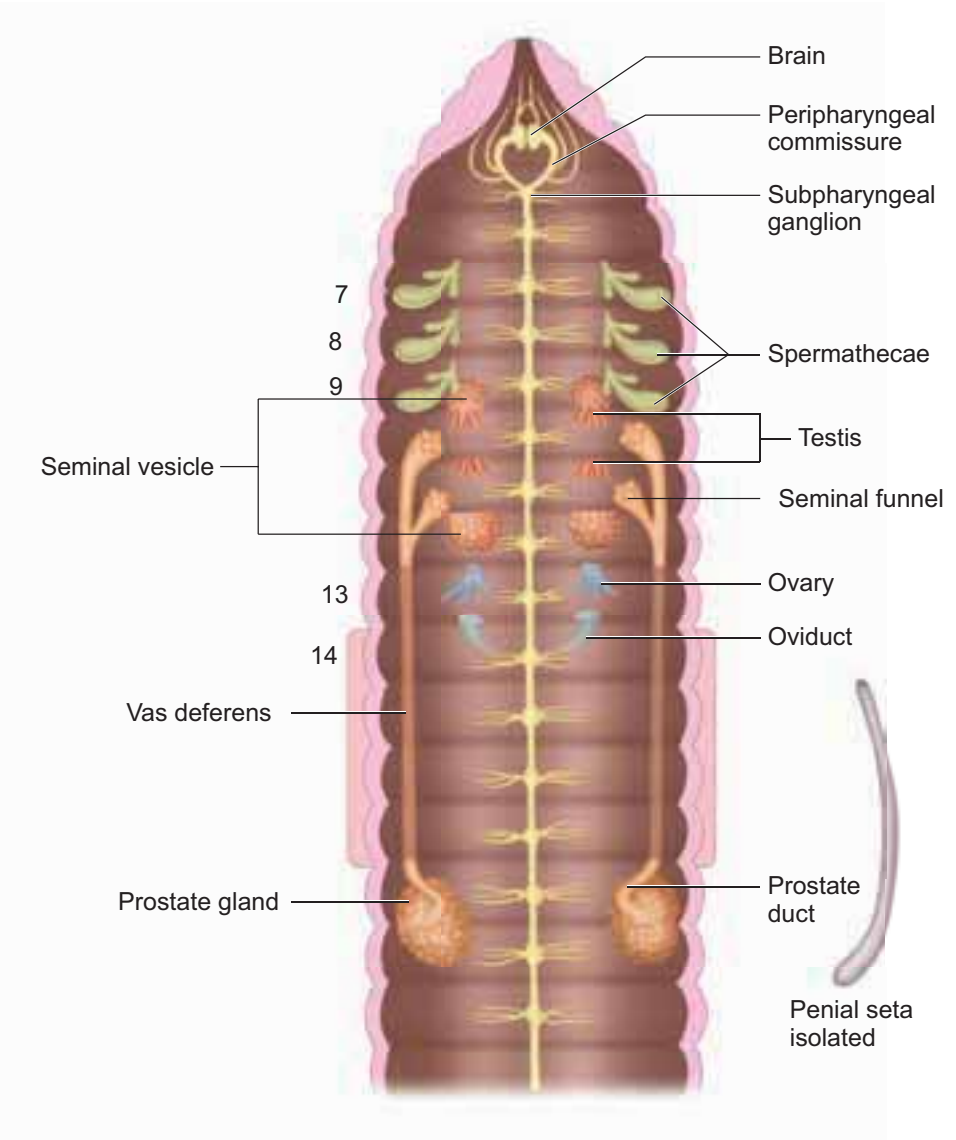

Figure: 4. 6 *Lampito mauritii*: Reproductive System.

Reproductive System

Earthworms are hermaphrodites or monoecious i.e. male and female reproductive organs are found in the same individual (Figure 4. 6). Self fertilization is avoided because two sex organs mature at different times, which means the sperm develops earlier than the production of ova **(Protandrous).** Thus cross fertilization takes place.

In the male reproductive system, two pairs of testes are present in the 10th and 11th segments. The testes give rise to the **germ cells** or **spermatogonia**, which develops into spermatozoa in the two pairs of seminal vesicles. Two pairs of seminal funnels called **ciliary rosettes** are situated in the same segments as the testes. The ciliated funnels of the same side are connected to a long tube called vas deferens. The **vasa deferentia** run upto the 18th segment where they open to the exterior through the **male genital aperture**. The male genital aperture contains two pairs of **penial setae** for copulation. A pair of prostate glands lies in the 18th – 19th segments. The secretion of the prostate gland serves to cement the spermatozoa into bundles known as **spermatophores**.

Regeneration

Earthworms have their most important organ in the first 20 segments. If earthworm gets cut after the 20th segment, the anterior half can regenerate, while the posterior half shall disintegrate after some time.

The female reproductive system consists of a pair of **ovaries** lying in the 13th segment. Each ovary has finger like projections which contain ova in linear series. Ovarian funnels are present beneath the ovaries which continue into the **oviducts**. They join together and open on the ventral side as a single median female genital pore in the 14th segment. **Spermathecae** or **seminal receptacles** are three pairs lying in segments 7th, 8th and 9th, opening to the exterior on the ventral side between 6th & 7th, 7th & 8th and 8th & 9th segments. They receive spermatozoa from the partner and store during copulation.

A mutual exchange of sperms occurs between two worms during mating. One worm has to find another worm and they mate juxtaposing opposite gonadal openings, exchanging the sperms. Mature egg cells in the nutritive fluid are deposited in the cocoons produced by the gland cells of the clitellum which also collects the partner's sperms from the spermthecae. Fertilization and development occurs within the cocoons, which are deposited in the soil. After about 2 – 3 weeks, each cocoon produces baby earthworms. Development is direct and no larva is formed during development.

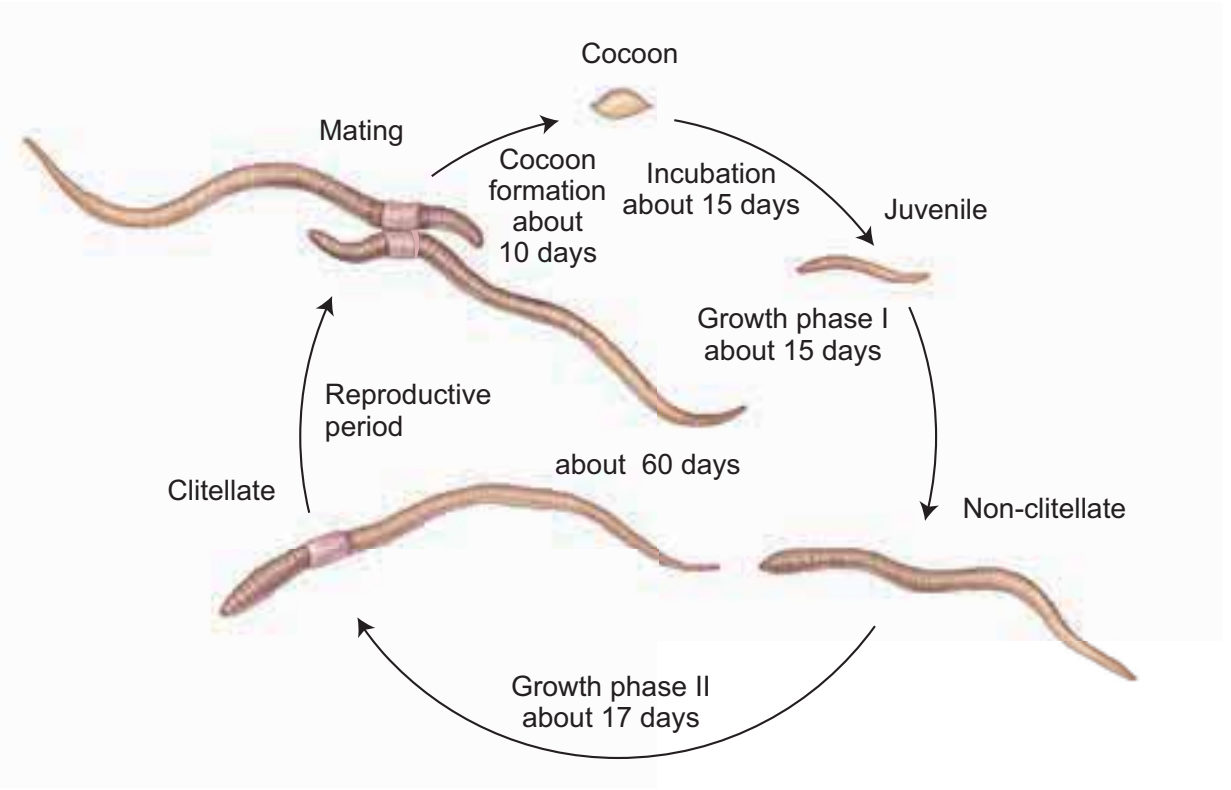

Figure 4.7 Life cycle of *Lampito mauritii*

Life cycle

Lampito mauritii begins its life cycle, from the fertilized eggs. The eggs are held in a protective cocoon. These cocoons have an incubation period of about 14- 18 days after which they hatch to release **juveniles** (Figure 4.7). The juveniles undergo changes into **non-clitellate** forms in phase – I after about 15 days, which then develops a clitellum, called the **clitellate** at the end of the growth phase – II taking 15 - 17 days to complete. During the reproductive stage, earthworms copulate, and later shed their cocoons in the soil after about 10 days. The life cycle of *Lampito mauritii* takes about 60 days to complete.

Earthworms are known as "friends of farmer" because they make burrows in the soil and make it porous which helps in respiration and penetration of developing plant roots. Vermiculture, vermicomposting, vermiwash and wormery are inter-linked and interdependent processes, collectively referred as **Vermitech**. *Lampito mauritti* helps in recycling of dead and decayed plant material by feeding on them. Artificial rearing or cultivation of earthworms involves new technology for the betterment of human beings. This process is known as **Vermiculture**. The process of producing compost using earthworms is called **Vermicomposting. Vermiwash** is a liquid manure or plant tonic obtained from earthworm. It is used as a foliar spray and helps to induce plant growth. It is a collection of excretory products and mucus secretion of earthworms along with micronutrients from the soil organic molecules. Earthworms can be used for recycling of waste food, leaf, litter and biomass to prepare a good fertilizer in container known as **wormery** or **wormbin**. It makes superior compost than conventional composting methods. Earthworms are also used as bait in fishing.

4.2 Cockroach -*Periplaneta americana*

Cockroach is a typical cosmopolitan insect and exhibits all the fundamental characteristics of Class Insecta. Generally cockroaches are reddish brown or black bodied with a light brown margin in the first thoracic segment. They are omnivores, nocturnal, living in damp and warm places and are quite common in kitchens, hotels, bakeries, restaurants, warehouse, sewage and public places. *Periplaneta* is a cursorial (swift runner) animal. It is dioecious and oviparous and exhibits parental care. They carry with them harmful germs of various bacterial diseases like cholera, diarrhoea, tuberculosis, and typhoid and hence are known as "**Vectors**".

Classification

Phylum	:	Arthropoda
Class	:	Insecta
Order	:	Orthoptera
Genus	:	*Periplaneta*
Species	:	*americana*

Morphology

The adult cockroaches are about 2 to 4 cm in length and about 1cm in width. The body of the cockroach is compressed dorso-ventrally, bilaterally symmetrical, segmented and is divisible into three distinct regions – head, thorax and abdomen. The entire body is covered

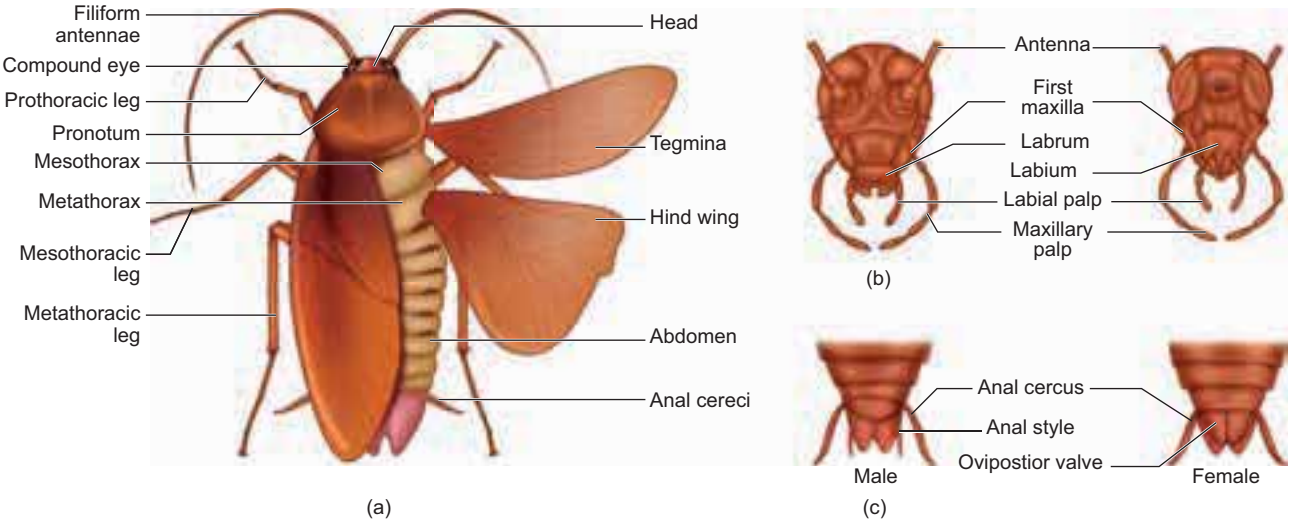

Figure 4.8 *Periplaneta americana:* (a) External features (b) Head dorsal and ventral view (c) Male and Female ventral view of posterior segment of abdomen

by a hard, brown coloured, chitinous exoskeleton. In each segment, exoskeleton has hardened plates called **sclerites**, which are joined together by a delicate and elastic **articular membrane** or **arthrodial membrane**. The sclerites of the dorsal side are called **tergites**, those on the ventral side are called **sternites** and those of lateral sides are called **pleurites**.

The head of cockroach is small, triangular lies at right angle to the longitudinal body **axis**. the mouth parts are directed downwards so it is **hypognathous.** It is formed by the fusion of six segments and shows great mobility in all directions due to a flexible neck (Figure 4.8). The head capsule bears a pair of large, sessile, and reniform **compound eyes**, a pair of antennae and appendages around the mouth. Antennae have sensory receptors that help in monitoring the environment. The appendages form the mouth parts which are of biting and chewing type (**Mandibulate** or **Orthopterus type**). The mouth parts consist of a **labrum** (upper lip), a pair of **mandibles**, a pair of **maxillae**, a **labium** (lower lip) and a **hypopharynx** (tongue) or **lingua** (Figure 4.9). The thorax consists of three segments – **Prothorax**, **Mesothorax** and **Metathorax**. The prothoracic segment is the largest. The head is connected with thorax by a short extension of the prothorax called as the **neck** or **cervicum**. Each thoracic segment bears a pair of walking legs. Due to the presence of three pairs of walking legs it is also called **hexapoda** (hexa-six, poda-feet) All the three pairs of walking legs are similar and each leg consists of five segments – **coxa** (large), **trochanter** (small), **femur** (long and broad), **tibia** (long and thick) and **tarsus**. The last segment of the leg - tarsus has five movable joints or **podomeres** or **tarsomeres**. Cockroach has two pairs of wings, the first pair arises from mesothorax and protects

The cockroaches are ancient and most basic among all groups of insects, dating back to the carboniferous period, about 320 million years ago.

the hind wings when at rest, and is called **elytra** or **tegmina**. The second pair of wings arises from the metathorax and are used in flight. The abdomen in both male and female consists of 10 segments. Each segment is covered by the dorsal tergum, the ventral sternum and between them a narrow membranous pleuron on each side. In females, the 7th sternum is boat shaped and together with the 8th and 9th sterna forms a brood or genital pouch whose anterior parts contains female gonopore, spermathecal pores, collaterial glands and posterior parts constitutes the oothecal chamber in which the cocoons are formed. In males, the genital pouch lies at the hind end of the abdomen bound dorsally by 9th and 10th terga and ventrally by the 9th sternum. It contains the dorsal anus and ventral male genital pore. In both the sexes, genital apertures are surrounded by sclerites called **gonapophysis**. Male bears a pair of short and slender **anal styles** in the 9th sternum which are absent in the female. In both sexes, the 10th segment bears a pair of jointed filamentous structures called **anal cerci** and bears a sense organ that is receptive to vibrations in air and land. The 7th sternum of male has a pair of large and oval apical lobes or gynovalvular plates which form a keel like structure which distinguishes the male from the female.

DO YOU KNOW?

One of the fastest moving land insects is the cockroach. They can move as fast as 5.4 Km per hour.

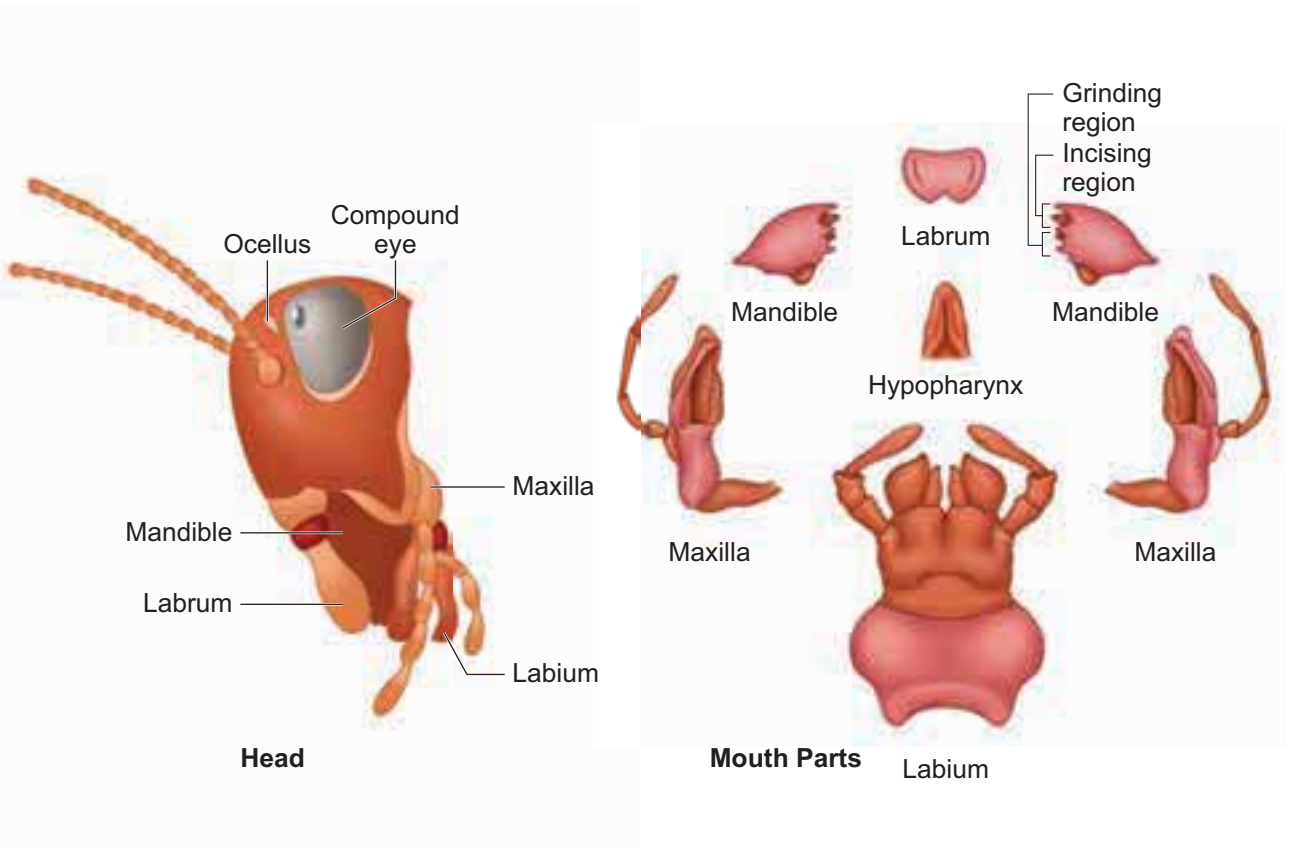

Figure 4.9 *Periplaneta americana*

Table 4.2: Differences between male and female cockroach

S. No	Character	Male cockroach	Female cockroach
1.	Abdomen	Long and narrow	Short and broad
2.	Segments	In the abdomen, nine segments are visible	In the abdomen, seven segments are visible
3.	Anal styles	Present	Absent
4.	Terga	7th tergum covers 8th tergum	7th tergum covers 8th and 9th terga
5.	Brood pouch	Absent	Present
6.	Antenna	Longer in length	Shorter in length
7.	Wings	Extends beyond the tip of abdomen	Extends up to the end of abdomen

Anatomy

Digestive system

The digestive system of cockroach consists of the alimentary canal and digestive glands. The alimentary canal is present in the body cavity and is divided into three regions: foregut, midgut and hindgut (Figure 4.10). The foregut includes pre-oral cavity, mouth, pharynx and oesophagus. This in turn opens into a sac like structure called the **crop** which is used for storing food. The crop is followed by the **gizzard** or **proventriculus** which has an outer layer of thick circular muscles and thick inner cuticle forming six highly chitinous plates called **"teeth"**. Gizzard helps in the grinding of the food particles. The midgut is a short and narrow tube behind the gizzard and is glandular in nature. At the junctional region of the gizzard are eight fingers like tubular blind processes called the **hapatic caecae** or **enteric caecae.** The hindgut is marked by the presence of 100 – 150 yellow coloured thin filamentous **malphigian** tubules which are helpful in removal of the excretory products from the haemolymph. The hindgut is broader than the midgut and is differentiated into ileum, colon, and rectum. The rectum opens out through the anus.

Digestive glands of cockroach consist of the salivary glands, the glandular cells and hepatic caecae. A pair of salivary glands is found on either side of the crop

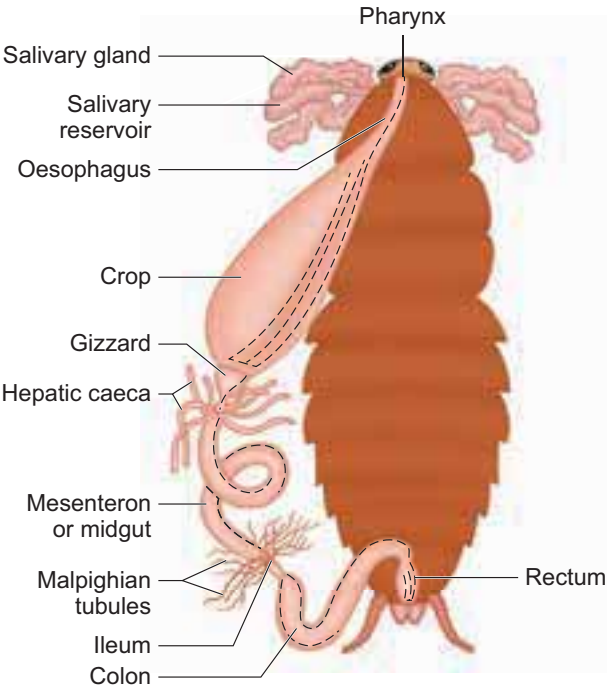

Figure 4.10 *Periplaneta americana*: Digestive system

in the thorax. The glandular cells of the midgut and hepatic or gastric caecae produce digestive juices.

6ARM2X

Respiratory system

The respiratory system of cockroach is well developed compared with other terrestrial insects (Figure 4.11). Branched tubes known as **trachea** open through 10 pairs of small holes called **spiracles** or **stigmata,** present on the lateral side of the body. Terminal branches of tracheal tubes are called **tracheoles** which carry oxygen to the entire body. The spiracles open and close by valves regulated by **sphincter** or **spiracular muscles**. Each tracheole is filled with a watery fluid through which exchange of gases takes place. During high muscular activity, a part of the fluid is drawn into the tissues to enable more oxygen intake and rapid diffusion. The passage of air in the tracheal system is:

SPIRACLES → TRACHEA
TISSUES ← TRACHEOLES

Respiratory system of cockroach is formed of spiracles and tracheal interconnections. Why is it said to be more efficient than that of earthworm? Why inspiration of cockroach is said to be a passive process while it is an active process in man?

Circulatory system

Periplaneta has an open type of circulatory system (Figure 4.12) Blood vessels are poorly developed and opens into the haemocoel in which the blood or

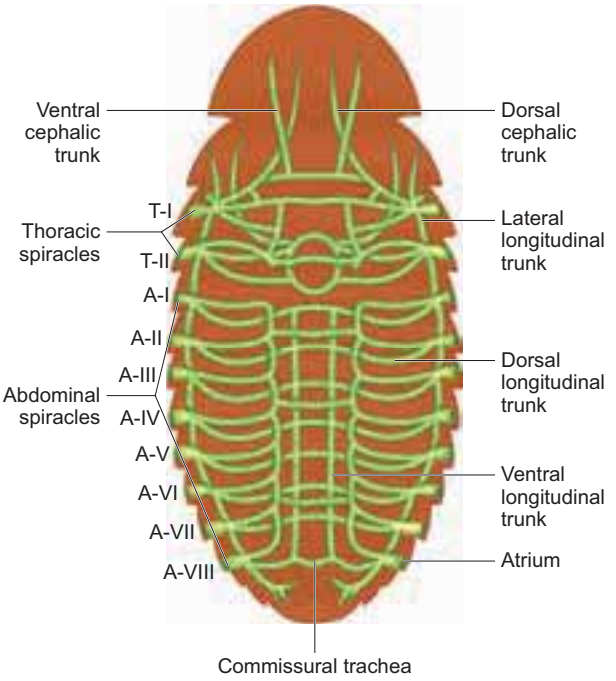

Figure 4.11 *Periplaneta americana*: Tracheal system in dorsal view

haemolymph flows freely. Visceral organs located in the haemocoel are bathed in blood. The haemolyph is colourless and consists of plasma and haemocytes which are 'phagocytic' in nature. Heart is an elongated tube with muscular wall lying mid dorsally beneath the thorax. The heart consists of 13 chambers with ostia on either side. The blood from the sinuses enters the heart through the **ostia** and is pumped anteriorly to sinuses again. The triangular muscles that are responsible for blood circulation in the cockroach are

Cockroaches survive without a head

A cockroach can live for about a week without its head. Due to their open circulatory system, and the fact that they breathe through little holes on each of their body segments, since they are not dependent on the mouth or head to breathe. The cockroach dies later due to starvation

DO YOU KNOW?

A **cockroach** can hold its breath for 45 minutes, and can even survive being submerged under water for half an hour. They hold their breath often to help regulate loss of water.

called **alary muscles** (13 pairs). One pair of these muscles is found in each segment on either side of the heart. In cockroach, there is an accessory **pulsatile vesicle** at the base of each antenna which also pumps blood.

Nervous system

The nervous system of cockroach consists of a **nerve ring** and a **ganglionated double ventral nerve cord**, **sub-oesophageal ganglion**, **circum–oesophageal connectives** and **double ventral nerve cord (Figure 4.13)**. The nerve ring is present around the oesophagus in the head capsule and is formed by the supra-oesophagial ganglion called the **'brain'**, The brain is mainly a sensory and an endocrine centre and lies above the oesophagus. Sub-oesophageal ganglion is the motor centre that controls the movements of the mouth parts, legs and wings. It lies below the oesophagus and formed by the fusion of the paired gangalia of mandibular, maxillary and labial segments of the head. A pair of circum–oesophageal connectives is present around the oesophagus, connecting the supra-oesophageal ganglia with the sub-oesophageal ganglion. The double ventral nerve cord is solid, ganglionated and arises from the sub-oesophageal ganglion and extends up to the 7th abdominal segment.

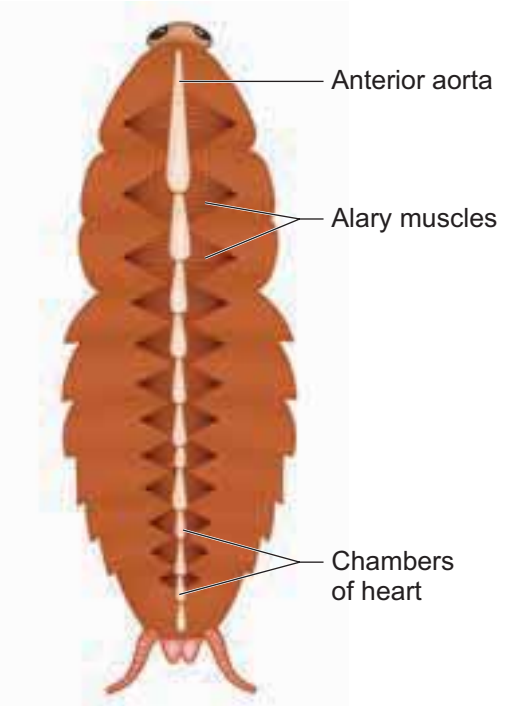

Figure 4.12 *Periplaneta americana*: Circulatory system

Three thoracic ganglia are present, one in each thoracic segment and six abdominal ganglia in the abdomen.

In cockroach, the sense organs are antennae, compound eyes, labrum, maxillary palps, labial palps and anal cerci. The receptor for touch (thigmo receptors) is located in the antenna, maxillary palps and cerci. The receptor for smell (olfactory receptors) is found on the antennae. The receptor for taste (gustatory receptors) is found on the palps of maxilla and labium. Thermoreceptors are found on the first four tarsal segments on the legs. The receptor chordotonal is found on the anal cerci which respond to air or earth borne vibrations. The photoreceptors of the cockroach consists of a pair of compound eyes at the dorsal surface of the head. Each eye is formed of about

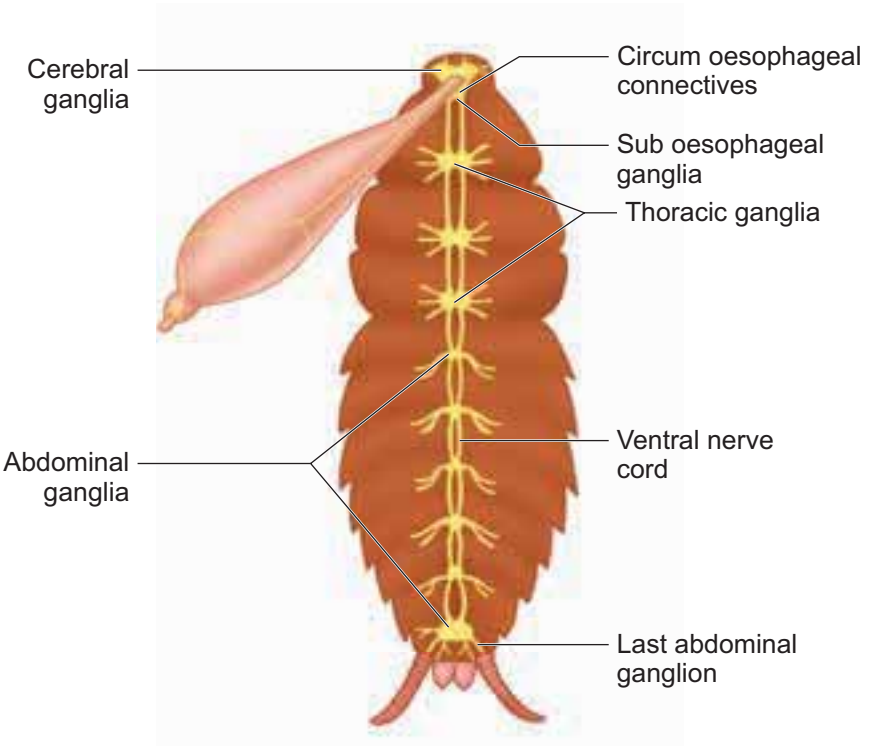

Figure 4.13 *Periplaneta americana*: Nervous system

2000 simple eyes called the **ommatidia** (singular: *ommatidium*), through which the cockroach can receive several images of an object. This kind of vision is known as mosaic vision with more sensitivity but less resolution.

Arthropod eyes are called compound eyes because they are made up of repeating units, the ommatidia, each of which functions as a separate visual receptor.

What is the difference between compound eyes and simple eyes?

Why is mosaic vision with less resolution seen in cockroaches?

Excretory system

The Malpighian tubules are the main excretory organs of cockroach which help in eliminating the nitrogenous wastes from the body in the form of uric acid. Cockroach excretes uric acid, so it is **uricotelic**. In addition, fat body, nephrocytes, cuticle, and urecose glands are also excretory in function.

The malpighian tubules are thin, long, filamentous, yellow coloured structures attached at the junction of midgut and hindgut. These are about 100-150 in number

DO YOU KNOW?

Marcello Malpighi – described these tubules and called them vasa varicose. Meckel later called them Malpighian tubules.

and are present in 6-9 bundles. Each tubule is lined by glandular and ciliated cells and the waste is excreted out through the hindgut. The glandular cells of the malpighian tubules absorb water, salts, and nitrogenous wastes from the haemolymph and transfer them into the lumen of the tubules. The cells of the tubules reabsorb water and certain inorganic salts. By the contraction of the tubules nitrogenous waste is pushed into the ileum, where more water is reabsorbed. It moves into the rectum and almost solid uric acid is excreted along with the faecal matter.

Reproductive system

Cockroach is dioecious or unisexual. They have well developed reproductive organs. The male reproductive system consists of a pair of testes, vasa deferentia, an ejaculatory duct, utricular gland, phallic gland and the external genitalia. A pair of three lobed testes lies on the lateral side of the 4th and 6th abdominal segments. From each testis arises a thin vas deferens, which opens into the ejaculatory duct through the seminal vesicles. The ejaculatory duct is an elongated duct which opens out by the male gonopore

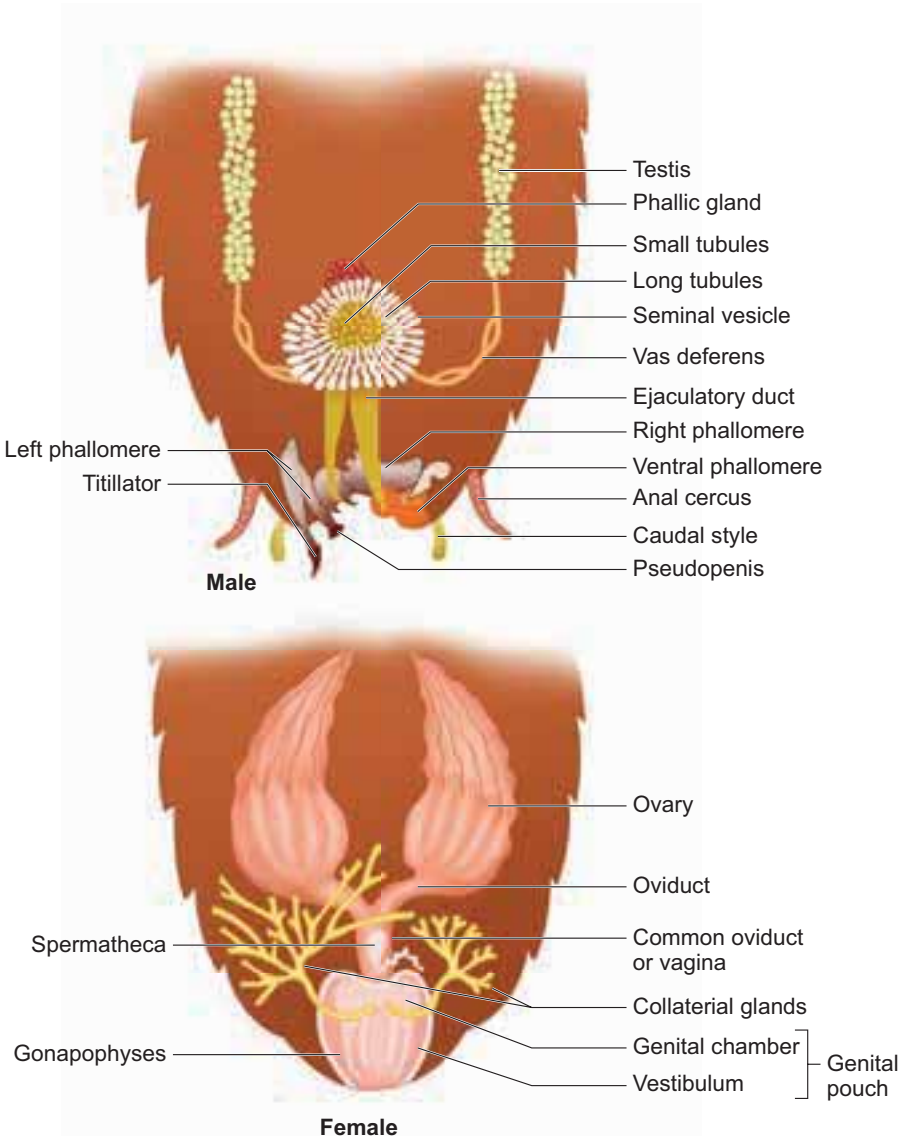

Figure 4.14 *Periplaneta americana reproductive system*

lying ventral to the anus. A utricular or mushroom shaped gland is a large accessory reproductive gland, which opens into the anterior part of the ejaculatory duct. The seminal vesicles are present on the ventral surface of the ejaculatory duct. These sacs store the sperms in the form of bundles called spermatophores. The duct of phallic or conglobate gland also opens near the gonopore, whose function is uncertain. Surrounding the male genital opening are few chitinous and asymmetrical structures called phallomeres or gonapophyses which help in copulation.

The female reproductive system of cockroach consists of a pair of ovaries, vagina, genital pouch, collaterial glands, spermathecae and the external genitalia. A pair of ovaries lies laterally in the 2nd and 6th abdominal segment. Each ovary is formed of a group of eight ovarian tubules or ovarioles, containing a chain of developing ova. The lateral oviducts of each ovary unite into a broad median common oviduct known as vagina, which opens into the genital chamber. The vertical opening of the vagina is the female genital pore. A pair of spermathecae is present in the 6th segment, which opens by a median aperture in the dorsal wall of the genital pouch. During copulation, the ova descend to the genital chamber, where they are fertilized by the sperms. A pair of white and branched collaterial glands present behind the ovaries forms a hard egg case called **Ootheca** around the eggs. Genital pouch is formed by the 7th, 8th and 9th abdominal sterna. The genital pouch has two chambers, a genital chamber into which the vagina opens and an oothecal chamber where oothecae are formed. Three pairs of plate like chitinous structures called gonapophyses are present around the female genital aperture. These gonapophyses guide the ova into the ootheca as ovipositors. (Figure 4. 14).

Ootheca is a dark reddish to blackish brown capsule about 12mm long which contains nearly 16 fertilized eggs and dropped or glued to a suitable surface, usually in crack or crevice of high relative humidity near a food source. On an average, each female cockroach produces nearly 15 – 40 oothecae in its life span of about one to two years. The embryonic development occurs in the ootheca, which takes nearly 5 – 13 weeks. The development of cockroach is gradual through nymphal stages (paurometabolus). The nymph resembles the adult and undergoes moulting. The nymph grows by moulting or ecdysis about 13 times to reach the adult form.

Many species of cockroaches are wild. About 30 cockroach species out of 4,600 are associated with human habitats. About four species are well known as pests. They destroy food and contaminate with their offensive odour. The mere presence of cockroaches is a sign of unhygienic condition and they are also known to be carriers of a number of bacterial diseases. The cockroach allergen can cause asthma to sensitive people.

Diploptera punctata, a viviparous cockroach, produces a nutritionally dense crystalline "milk" to feed their live-born young. It is found in Myanmar, China, Fiji, Hawaii, and India. Scientists think Cockroach milk could be the super food of the future.

COCKROACHES

Cockroaches have been around since the time of dinosaurs!

American Cockroach
The American Cockroach is the largest cockroach found in houses. Females can hatch up to 150 offspring per year. Cockroaches don't develop wings until they become adults.

German Cockroach
German cockroaches can be found all over the world. They are the most common cockroach in the United States. Each German cockroach can live about 100-200 days.

Brown-banded Cockroach
The wings of male cockroaches are larger than the female's wings. Brown-banded cockroaches often hide their eggs in or under furniture. They usually live for 5-6½ months.

Oriental Cockroach
They are actually from Africa. They are large and very dark compared to other cockroaches. They usually travel through sewer pipes and drains. They prefer dirty places and cooler temperatures than other cockroaches.

Viviparous Cockroach
Diploptera punctata is a species of cockroach in the family Blaberidae. It is one of the few cockroach species that is viviparous. Adults are chemically defended, having a modified tracheal gland and spiracle on each side which squirts quinones which can poison or discourage a predator.

Facts

- *Cockroaches are known to carry diseases like dysentery, typhoid and poliomyelitis, as well as gastroenteritis.*
- *According to The National Cooperative Inner-City Asthma Study (NCICAS) – 23 percent to 60 percent of urban residents with asthma are sensitive to the cockroach allergens.*
- *Cockroaches have been implicated in the spread of 33 kinds of bacteria, including E. coli and Salmonella species, six parasitic worms and more than seven other types of human pathogens.*

4.3 The Common Indian Green Frog - *Rana hexadactyla*

About 360 million years ago, amphibians were the first vertebrates to live on land. Amphibians are diverse, widespread, and abundant group since the early diversification. There are about 4,500 species of amphibians. Frog is an amphibian and hence placed in the class Amphibia [Greek. *Amphi* - Both, *bios* – life]. The largest order, with more than 3,900 species, is Anura, which includes the **frogs** and **toads**. *Rana hexadactyla* is placed in the order Anura. Frogs live in fresh water ponds, streams and in moist places. They feed on small animals like insects, worms, small fishes, slugs, snails, etc. During its early development a frog is fully aquatic and breathes like a fish with gills. It is **poikilothermic**, i.e., their body temperature varies with the varying environmental temperature.

Classification

Phylum	:	Chordata
Class	:	Amphibia
Order	:	Anura
Genus	:	*Rana*
Species	:	*hexadactyla*

Morphology of Frog

The body of a frog is **streamlined** to help in swimming. It is dorso-ventrally flattened and is divisible into head and trunk. Body is covered by a smooth, slimy skin loosely attached to the body wall. The skin is dark green on the dorsal side

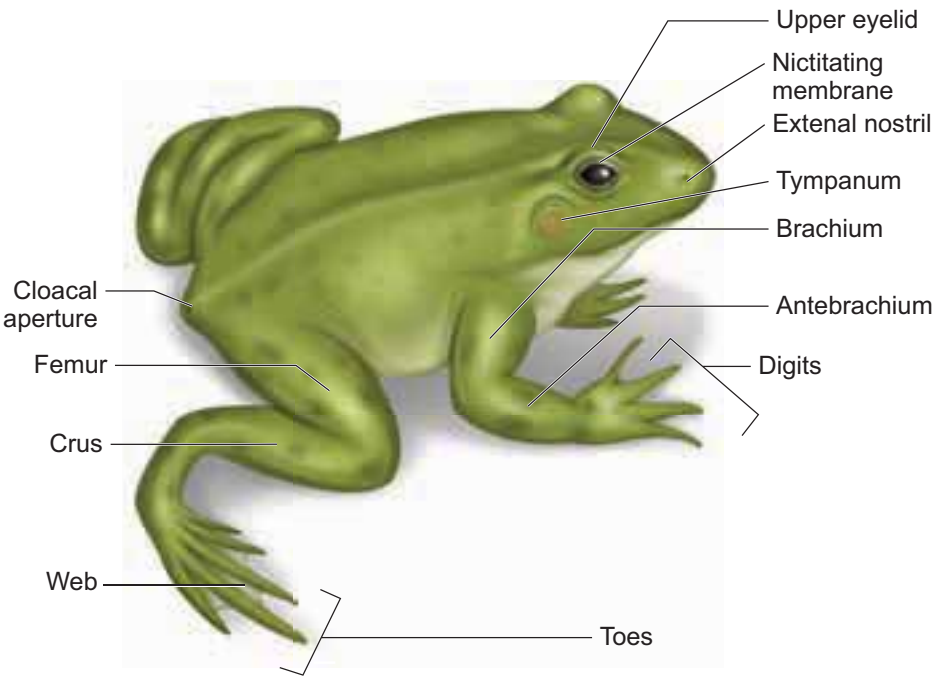

Figure 4.15 *Rana hexadactyla* - External morphology

Table 4.3: Differences between a Frog and Toad

Characters	 Frog	 Toad
Family	Ranidae	Bufonidae
Body shape	Slender	More Bulky
Legs	Longer	Shorter
Webbed feet	present	Absent
Skin	Smooth and moist skin	Dry skin covered with wart like glands.
Teeth	Maxillary and vomerine teeth.	Teeth absent.
Egg formation	Lays eggs in clusters.	Lays eggs in strings.

and pale ventrally. The head is almost triangular in shape and has an apex which forms the snout. The mouth is at the anterior end and can open widely. External nostrils are present on the dorsal surface of the snout, one on each side of the median line (Figure 4.15). Eyes are large and project above the general surface of the body. They lie

DO YOU KNOW?

Order - Anura (Frogs and Toads)

Frogs and toads have bodies specially designed for jumping with greatly elongated hind limbs. Frogs can live in water (aquatic), on land (terrestrial), or on trees (arboreal). Parental care is seen in few species.

behind the external nostrils and are protected by a thin movable lower eyelid, thick immovable upper eyelid and a third transparent eyelid called **nictitating membrane**. This membrane protects the eye when the frog is under water. A pair of **tympanic membranes** forms the ear drum behind the eyes on either side. Frogs have no external ears, neck and tail are absent. Trunk bears a pair of fore limbs and a pair of hind limbs. At the posterior end of the dorsal side, between the hind limbs is the **cloacal aperature**. This is the common opening for the digestive, excretory and reproductive systems.

Fore limbs are short, stumpy, and helps to bear the weight of the body. They are also helpful for the landing of the frog after leaping. Each forelimb consists of an upper arm, fore arm and a hand. Hand bears four digits. **Hind limbs** are large, long and consist of thigh, shank and foot. Foot bears five long webbed toes and one small spot called the sixth toe. These are adaptations for leaping and swimming. When the animal is at rest, the hind limbs are kept folded in the form of letter **'Z'**. **Sexual dimorphism** is exhibited clearly during the breeding season. The male frog has a pair of **vocal sacs** and a copulatory or **nuptial pad** on the ventral side of the first digit of each forelimb (Figure 4.16). Vocal sacs assist in amplifying the croaking sound of frog. Vocal sacs and nuptial pads are absent in the female frogs.

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Why three chambered heart of frog is not as efficient has the four chambered heart of birds and mammals?

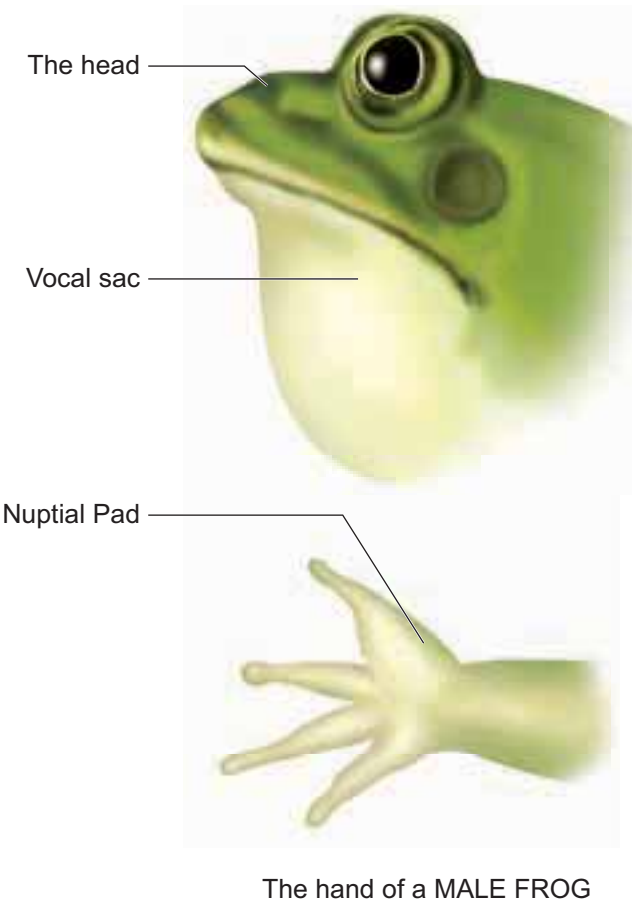


Figure 4.16 Male *Rana hexadactyla* with vocal sacs and nuptial pad

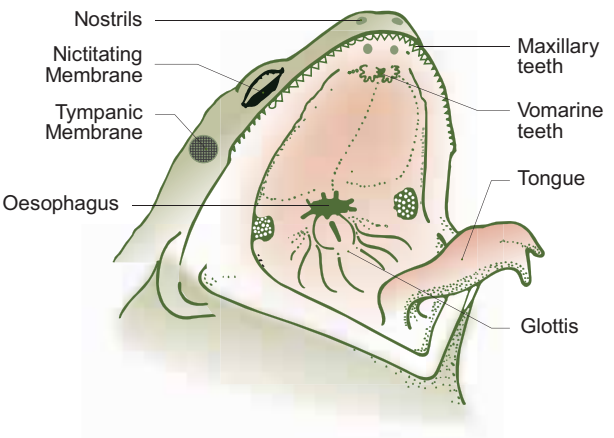


Figure 4.17 The Buccal Cavity of *Rana hexadactyla*

Anatomy

The Digestive System

The **alimentary canal** consists of the buccal cavity, pharynx, oesophagus, duodenum, ileum and the rectum which leads to the cloaca and opens outside by the cloacal aperture. The wide mouth opens into the buccal cavity. On the floor of the **buccal cavity** lies a large **muscular sticky tongue**. The tongue is attached in front and free behind. The free edge is forked. When the frog sights an insect it flicks out its tongue and the insect gets glued to the sticky tongue. The tongue is immediately withdrawn and the mouth closes. A row of small and pointed **maxillary teeth** is found on the inner region of the upper jaw (Figure. 4.17) In addition **vomerine teeth** are also present as two groups, one on each side of the internal nostrils. The lower jaw is devoid of teeth. The mouth opens into the buccal cavity that leads to the **oesophagus** through the **pharynx**. Oesophagus is a short tube that opens into the stomach and continues as the intestine, rectum and finally opens outside by the cloaca

Anus The opening at the lower end of the alimentary canal in mammals through which solid waste leaves the body.

Cloaca The common chamber into which the intestinal, urinary and genital tracts open. It is present in birds, reptiles, amphibians, elasmobranch fishes and monotremes. The cloaca has an opening for expelling its contents from the body and in females it serves as the depository for sperm.

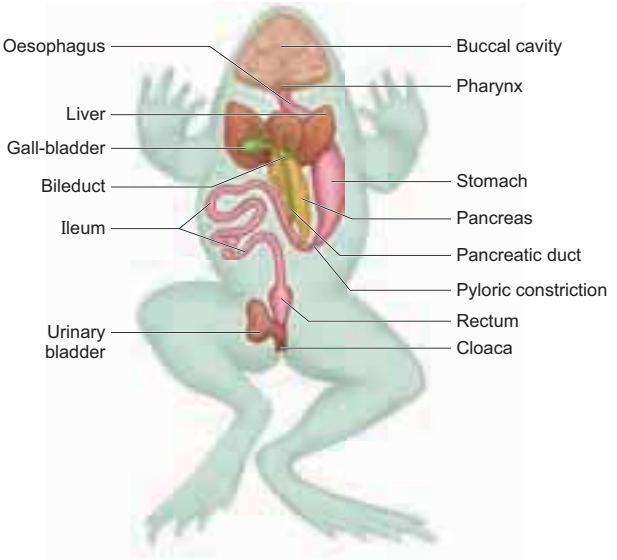


Figure: 4.18. Digestive System of *Rana hexadactyla*

(Figure 4. 18). **Liver** secretes bile which is stored in the gall bladder. **Pancreas**, a digestive gland produces pancreatic juice containing digestive enzymes.

Food is captured by the bilobed tongue. Digestion of food takes place by the action of **Hydrochloric acid** and **gastric juices** secreted from the walls of the stomach. Partially digested food called chyme is passed from the stomach to the first part of the intestine, the duodenum. The duodenum receives bile from the gall bladder and pancreatic juices from the pancreas through a common bile duct. **Bile** emulsifies fat and **pancreatic juices** digest carbohydrates, proteins and lipids. Final digestion takes place in the intestine. Digested food is absorbed by the numerous finger-like folds in the inner wall of **intestine** called **villi** and **microvilli.** The undigested solid waste moves into the **rectum** and passes out through the **cloaca.**

Respiratory System

Frog respires on land and in the water by two different methods. In water, **skin** acts

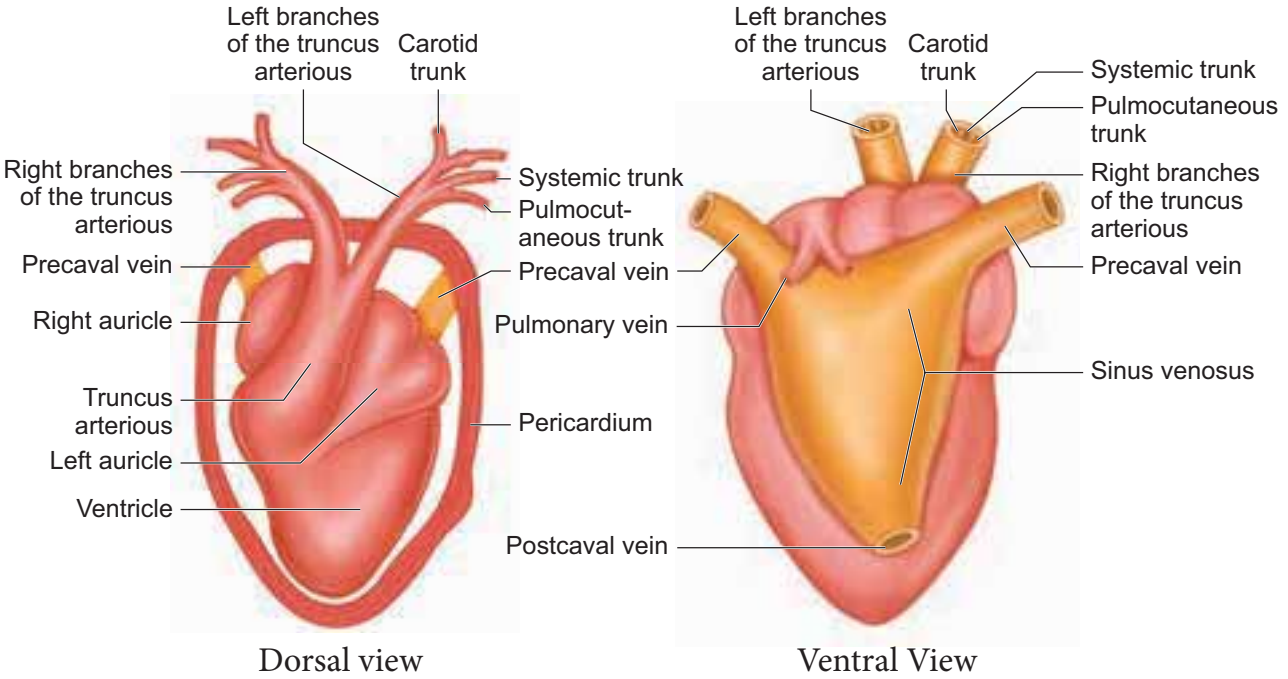


Figure 4.19 *Rana hexadactyla:* Structure of Heart

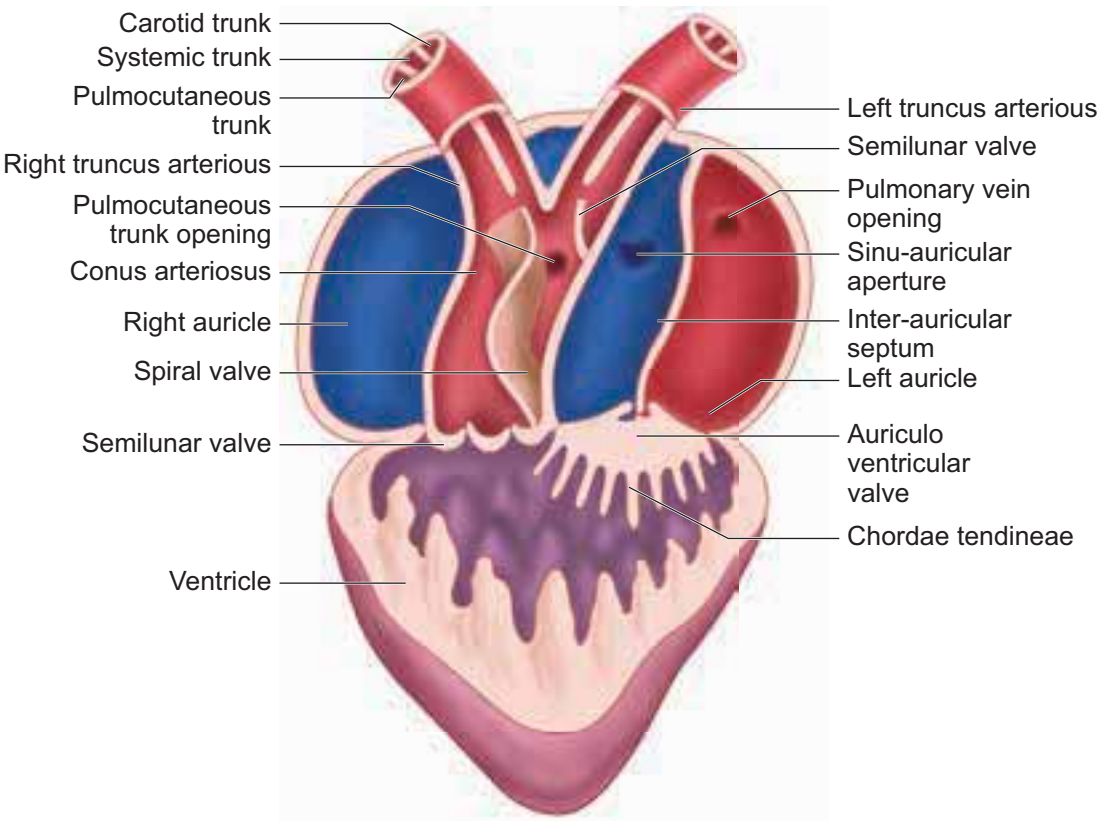


Figure 4.20 *Rana hexadactyla:* Internal Structure of Heart

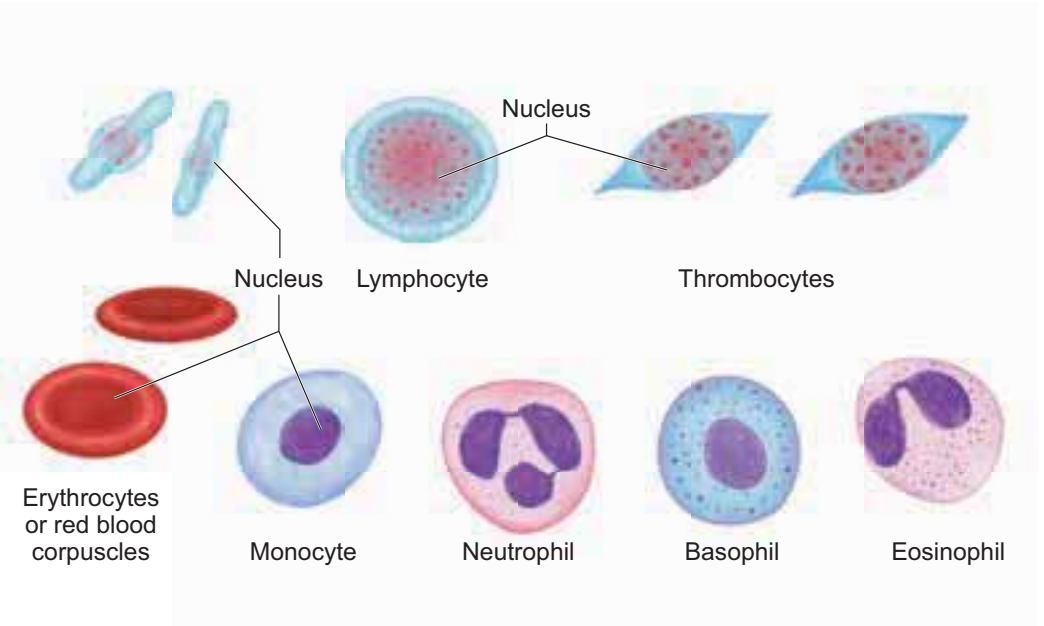


Figure 4.21 *Rana hexadactyla* – Blood cells

as aquatic respiratory organ (**cutaneous respiration**). Dissolved oxygen in the water gets, exchanged through the skin by diffusion. On land, the buccal cavity, skin and lungs act as the respiratory organs. In **buccal respiration** on land, the mouth remains permanently closed while the nostrils remain open. The floor of the buccal cavity is alternately raised and lowered, so air is drawn into and expelled out of the buccal cavity repeatedly through the open nostrils. Respiration by lungs is called **pulmonary respiration**. The lungs are a pair of elongated, pink coloured sac-like structures present in the upper part of the trunk region (thorax). Air enters through the nostrils into the buccal cavity and then to the lungs. During **aestivation** and **hibernation** gaseous exchange takes place through skin.

The Blood-Vascular System

Blood vascular system consists of a **heart** with three chambers, **blood vessels** and **blood**. Heart is covered by a double-walled membrane called **pericardium**. There are two thin walled anterior chambers called auricles (Atria) and a single thick walled posterior chamber called ventricle. **Sinus venosus** is a large, thin walled, triangular chamber, which is present on the **dorsal side** of the heart. **Truncus arteriosus** is a thick walled and cylindrical structure which is obliquely placed on the **ventral surface** of the heart. It arises from the ventricle and divides into right and left **aortic trunk,** which is further divided into **three aortic arches** namely carotid, systemic and pulmo-cutaneous. The **Carotid** trunk supplies blood to the anterior region of the body. The **Systemic trunk** of each side is joined posteriorly to form the **dorsal aorta.** They supply blood to the posterior part of the body. **Pulmo-cutaneous trunk** supplies blood to the lungs and skin. Sinus venosus receives the deoxygenated blood from the body parts by two anterior precaval veins and one post caval vein. It delivers the blood to the right auricle; at the same time left auricle receives oxygenated blood through the pulmonary vein. Renal portal and hepatic portal systems are seen in frog (Figure. 4.19 and 420).

The **blood** consists of **plasma** [60%] and blood **cells** [40 %], red blood cells, white blood cells, and platelets. RBCs are loaded with red pigment, nucleated and oval in shape. Leucocytes are nucleated, and circular in shape (Figure 4.21).

The Nervous System

The Nervous system is divided into the Central Nervous System [CNS], the Peripheral Nervous System [PNS], and the Autonomous Nervous System [ANS]. **Peripheral Nervous System** consists of 10 pairs of **cranial nerves** and 10 pairs of **spinal nerves**. **Autonomic Nervous System** is divided into **sympathetic** and **parasympathetic** nervous system. They control involuntary functions of **visceral organs**. CNS consists of the Brain and Spinal cord. Brain is situated in the cranial cavity and covered by two meninges called piamater and duramater. The brain is divided into forebrain, midbrain and hindbrain. Fore brain (Prosencephalon) is the anterior most and largest part consisting of a pair of **olfactory lobes** and **cerebral hemisphere** (as Telencephalon) and a **diencephalon**. Anterior part of the olfactory lobes is narrow and free but is fused posteriorly. The **olfactory lobes**

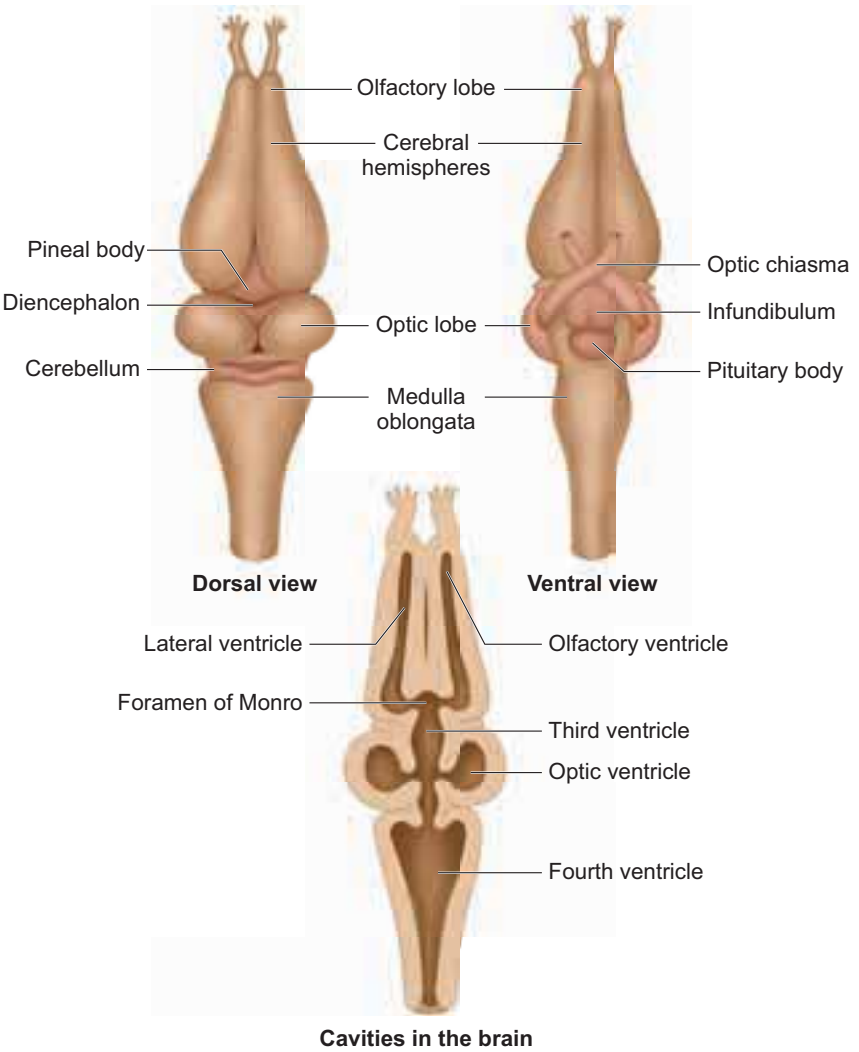


Figure: 4. 22 *Rana hexadactyla* – Brain dorsal and ventral view

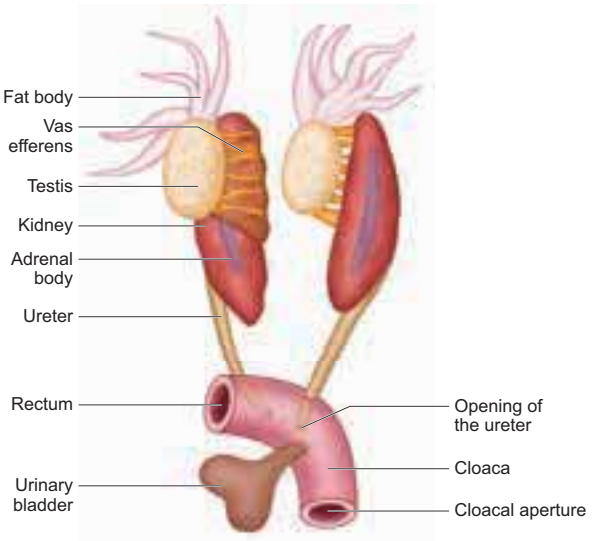


Figure 4.23 *Rana hexadactyla* - Male Urinogenital System

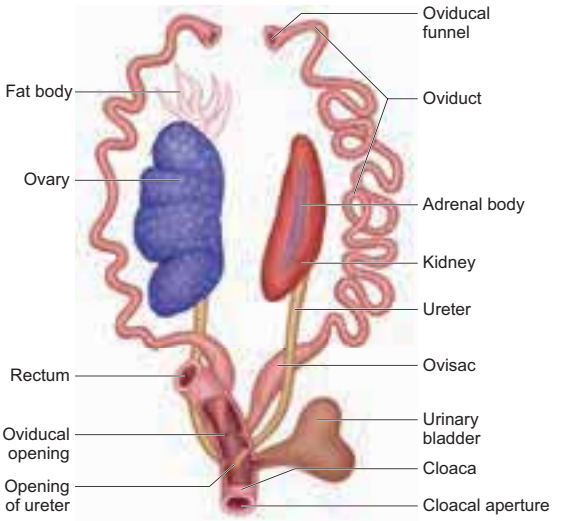


Figure 4.24 *Rana hexadactyla* - Female Urinogenital System

contain a small cavity called **olfactory ventricle**. The mid brain (Mesencephalon) includes two large, oval **optic lobes** and has cavities called **optic ventricles**. The hind brain (Rhombencephalon) consists of the **cerebellum** and **medulla oblongata**. Cerebellum is a narrow, thin transverse band followed by **medulla oblongata.** The medulla oblongata passes out through the **foramen magnum** and continues as **spinal cord,** which is enclosed in the vertebral column (Figure 4.22).

Excretory system

Elimination of **nitrogenous waste** and salt and water balance are performed by a well developed excretory system. It consists of a pair of kidneys, ureters, urinary bladder and cloaca. Kidneys are dark red, long, flat organs situated on either sides of the vertebral column in the body cavity. Kidneys are **Mesonephric.** Several nephrons are found in each kidney. They separate nitrogenous waste from the blood and excrete urea, so frogs are called **ureotelic** organisms. A pair of ureters emerges from the kidneys and opens into the cloaca. A thin walled unpaired **urinary bladder** is present ventral to the **rectum** and opens into the **cloaca.**

Reproductive system

The **male** frog has a pair of testes which are attached to the kidney and the dorsal body wall by folds of peritonium called mesorchium. Vasa efferentia arise from each **testis**. They enter the kidneys on both side and open into the bladder canal. Finally, it communicates with the urinogenital duct that comes out of kidneys and opens into the cloaca (Figure 4.23).

Female reproductive system (Figure 4.24) consists of paired **ovaries,** attached to the kidneys, and dorsal body wall by folds of peritoneum called mesovarium. There is a pair of coiled **oviducts** lying on the sides of the kidney. Each oviduct opens into the body-cavity at the anterior end by a funnel like opening called ostia. Unlike the male frog, the female frog has separate genital ducts distinct from ureters. Posteriorly the oviducts dilated to form **ovisacs** before they open into cloaca. Ovisacs store the eggs

temporarily before they are sent out through the cloaca. Fertilization is external.

Within few days of fertilization, the **eggs** hatch into **tadpoles**. A newly hatched tadpole lives off the yolk stored in its body. It gradually grows larger and develops three pairs of gills. The tadpole grows and **metamorphosis** into an air – breathing carnivorous adult frog (Figure 4.25). Legs grow from the body, and the tail and gills disappear. The mouth broadens, developing teeth and jaws, and the lungs become functional.

Economic importance of Frog

- Frog is an important animal in the **food chain**; it helps to maintain our ecosystem. So '**frogs should be protected**'.
- Frog are beneficial to man, since they feed on insects and helps in reducing insect pest population.
- Frogs are used in traditional medicine for controlling **blood pressure** and for its **anti aging** properties.
- In USA, Japan, China and North East of India, frogs are **consumed** as delicious food as they have high nutritive value.

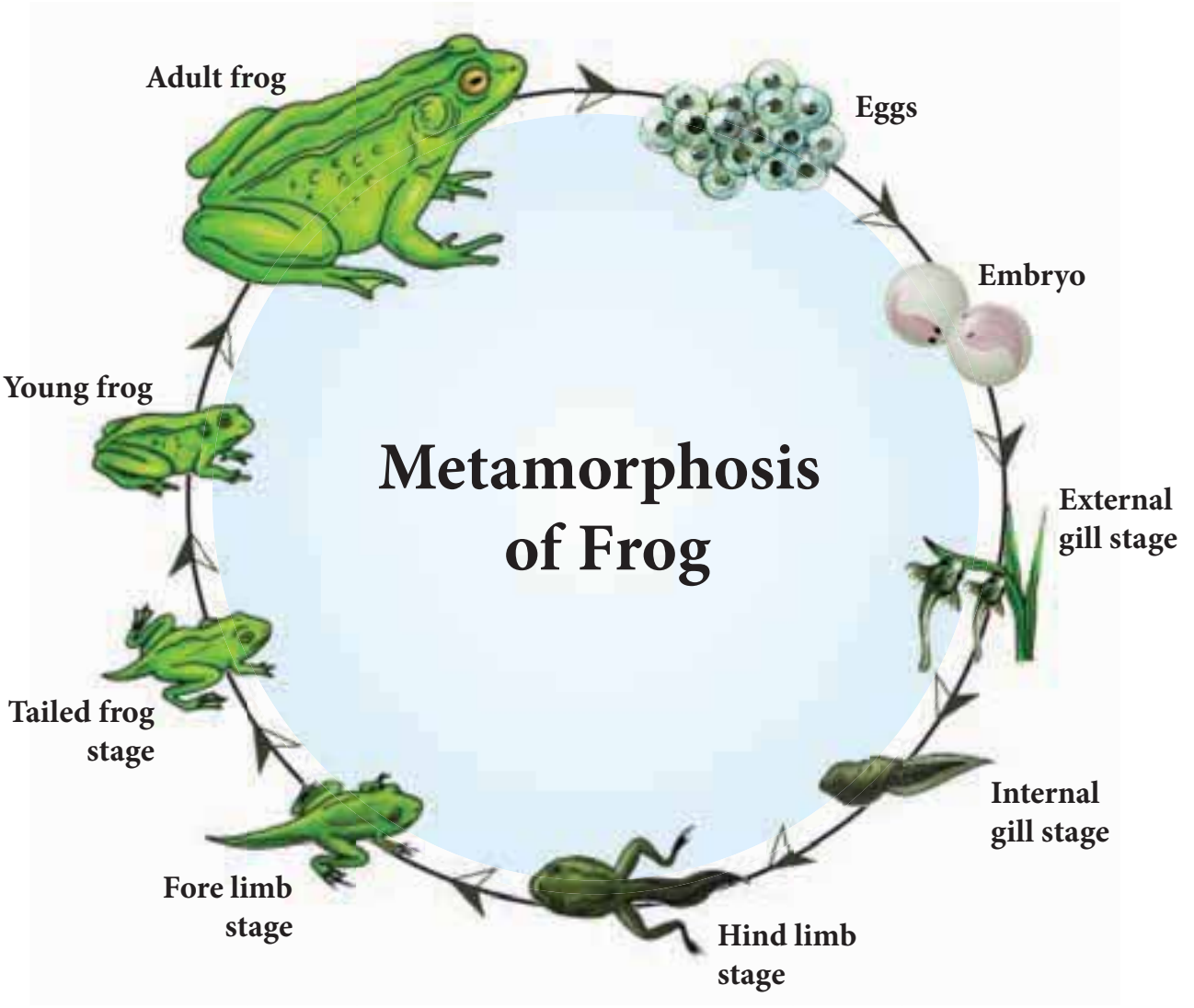


Figure 4.25 *Rana hexadactyla* - Metamorphosis

4. 4 Pigeon - *Columba livia*

Birds belong to the Class Aves (L. *avis* - birds). The most distinguishing feature of birds is the possession of feathers. The study of birds is **Ornithology**. A bird is a **feathered, bipedal, flying vertebrate** possessing **wings.** Their external and internal organization correlates with its aerial habit. More than 500 species of pigeon exist throughout the world. In India, about 10 species of pigeons are found. ***Columba livia*** is found throughout India (Figure 4.26).

Classification

Phylum	:	Chordata
Class	:	Aves
Order	:	Columbiformes
Genus	:	Columba
Species	:	*livia*

External features

The compact, boat shaped streamlined body of pigeon is well adapted for their aerial mode of life. The body of pigeon is

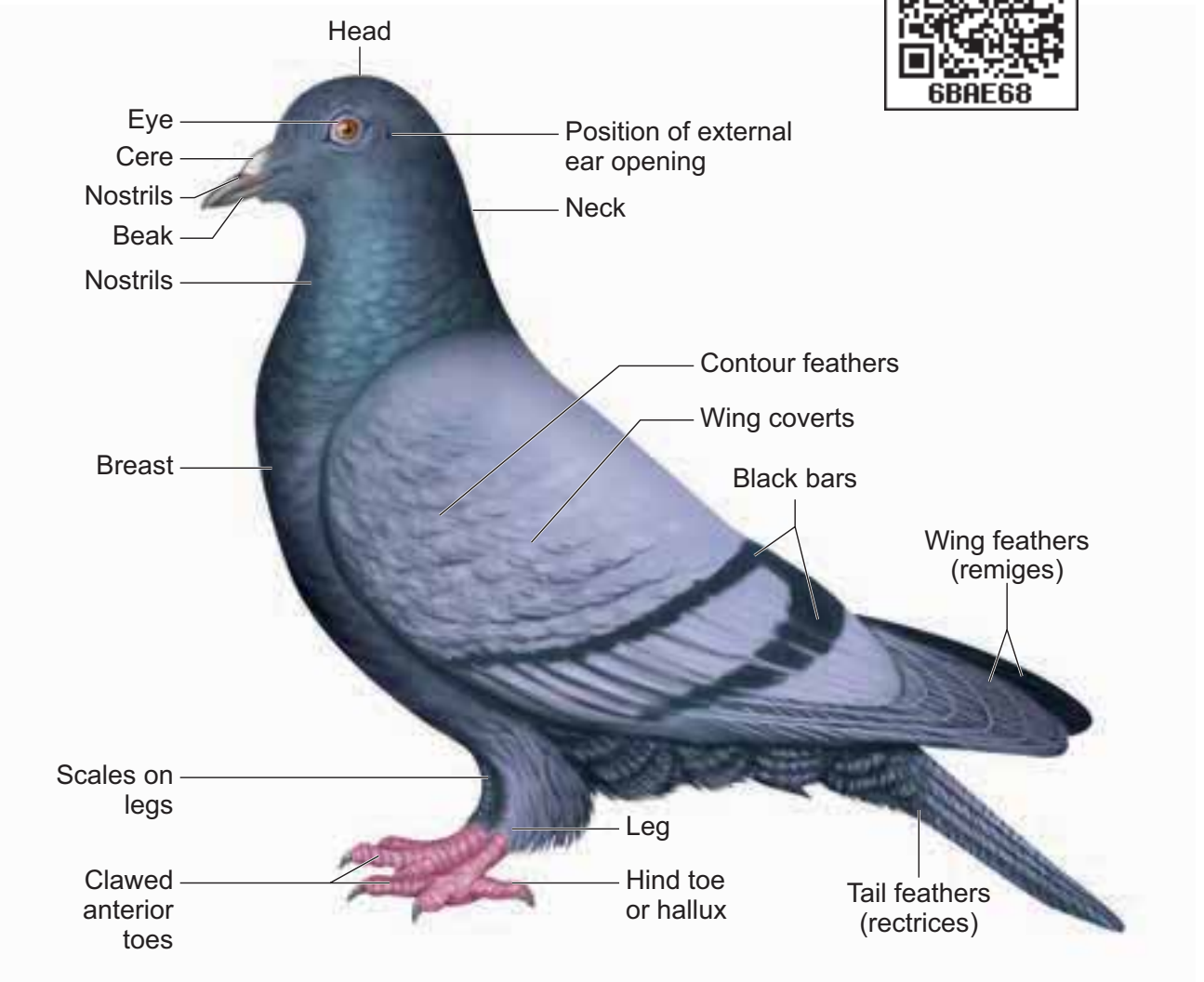


Figure 4.26 Columba livia – Common Rock Pigeon-External Features

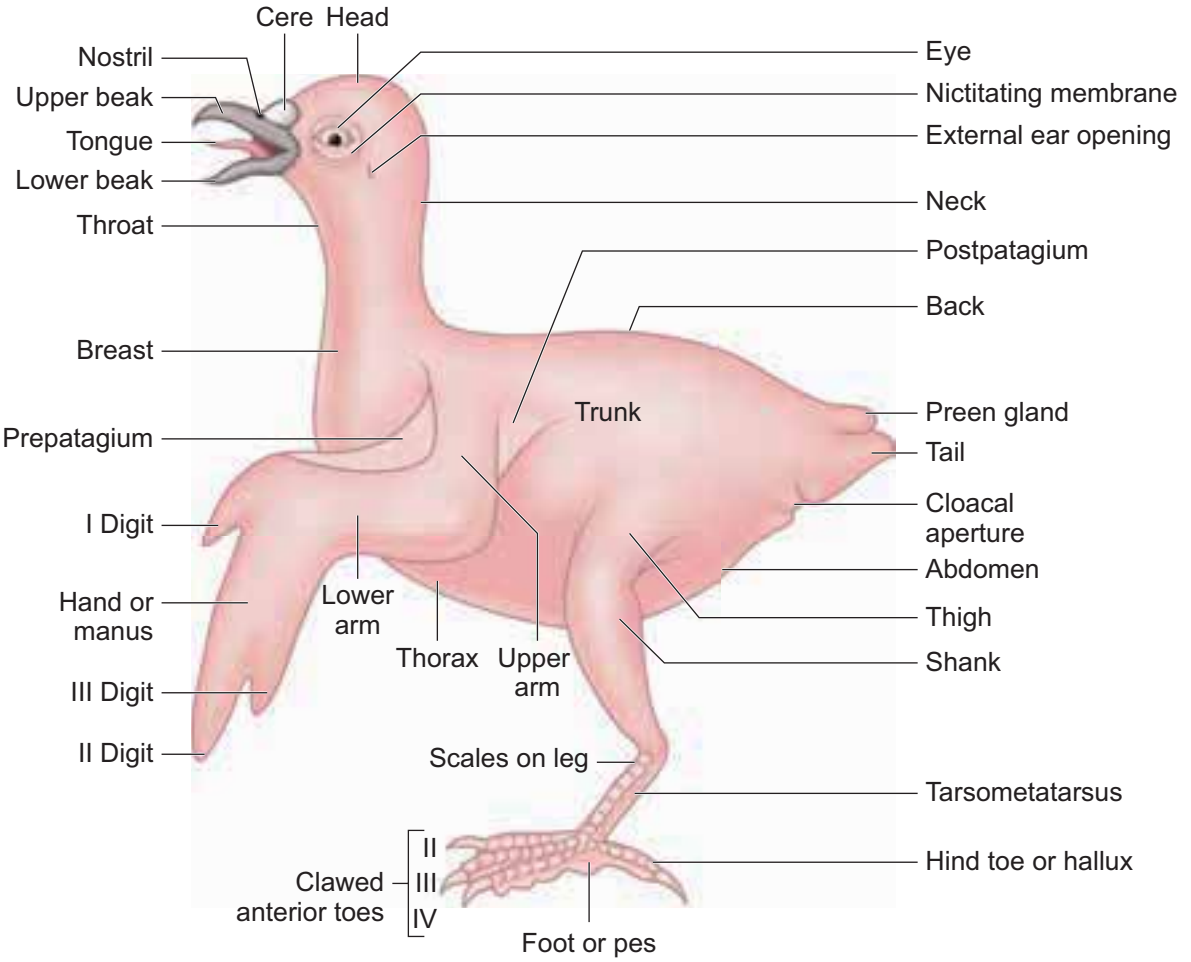


Figure 4.27 Pigeon Defeathered bird in left lateral view

divisible into head, neck, trunk and tail. **Head** is comparatively small, spherical and situated at the anterior most part of the body. **Beaks** present anteriorly are formed by the elongation of upper and lower jaw and they are devoid of teeth. At the base of the beak are the **external nostrils** overhung by a swollen, sensitive soft skin called **cere**. **Eyes** are prominent, round and laterally present. Eyes are protected by an upper eyelid, lower eyelid, and a transparent **nictitating membrane**. Posterior to the eyes are the **ear** openings which lead to the **tympanic membrane** by a short tube, **external auditory meatus**. **Neck** is flexible, cylindrical and long which connects the head with the **trunk.** The spindle shaped trunk bears a pair of **wings** and a pair of **legs**. The **cloacal aperture** opens ventrally at the hind end of the trunk. Dorsally the base of the tail has a knob like papilla, which bears the opening of the **preen gland** or **uropygial gland**. It is the only cutaneous gland present and its oily secretion is used for lubricating or preening the feathers. The tail is used as a rudder in flight. **Fore limbs** are modified into wings. The wings have three typical regions, the upper arm (brachium), lower arm (ante-brachium) and the hand (manus). Three clawless and imperfectly marked digits are present on each hand. While at rest, each forelimb is folded in the form of **'Z'**; during flight they are extended. With the modification of the forelimbs for flight, the whole weight of the body is

supported by the **hind limbs**, while the bird is at rest or walking; the hind limbs are therefore attached anteriorly from the trunk to balance the body and support the weight of the body at rest. They are warm blooded or **homeothermic**.

Exoskeleton

The exoskeleton of pigeon is derived from the **epidermis** and occurs in the form of **horny claws, scales** and **feathers**. Beaks are used for ingestion, fighting and preening of feathers. Claws are used for walking and perching. Epidermal scales are present on the foot and the entire body is covered by feathers. Arrangement of feathers on the body of bird is called **pterylosis**. Feathers are of three kinds: large **quill feathers** on wings and tail which are used for flight; **contour feathers**, form a covering for the body and **filoplumes,** lie between the contour feathers. The **nestlings** are covered with **down feathers** which resemble the filoplumes.

Structure of a Quill feather

The quill feather has a **stem** or **scapus** and is divided into a lower hollow part called **calamus** or **quill** and an upper solid portion called **rachis**. Lower end of the stem has an opening called **inferior umbilicus** which receives a dermal papilla, supplying nutrients and pigments for the growing feathers (Figure 4.28)

A second opening the **superior umbilicus** occurs at the junction of the quill and the rachis, on the inner face of the feather; close to this opening is a small tuft of soft feathers called **after shaft**. Attached to the rachis are small **filament** or **barbs**; the rachis with the barbs constitute the **vane** or

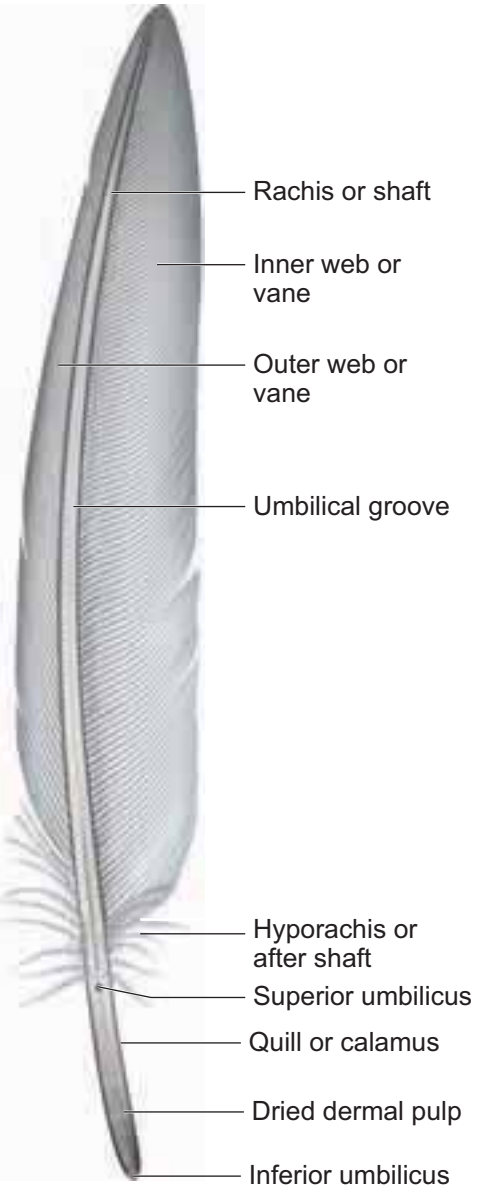


Figure 4.28 Quill Feather

the **vexillum**. Each barb is fringed with an oblique set of processes called **barbules**, which have minute **hooklets** or **barbicels** by which adjacent barbs are hooked together to form a continuous blade for striking the air during flight.

Anatomy

Endoskeleton

The skeletal system is strong but lightly built. The bones are light and spongy. Many of the long bones contain air instead of

marrow (Pneumatic bones). This reduces the weight of the body. The **breast bone** or **sternum** has a broad plate of bone produced ventrally into a prominent vertical **crest** or **keel** to which the powerful muscles of flight are attached.

Flight muscles

Wings are modified forelimbs and the organs of flight. The musculature of the forelimbs are greatly modified in response to the function they perform. Flight is the coordinated effort of a number of paired muscles. The muscles which operate the wings during flight are called **flight muscles**. The major flight muscles of pigeon are the **pectoral muscles**. Pectoral muscles are of two types namely the **Pectoralis major** and **Pectoralis minor**. The pectoralis major muscle is a large and

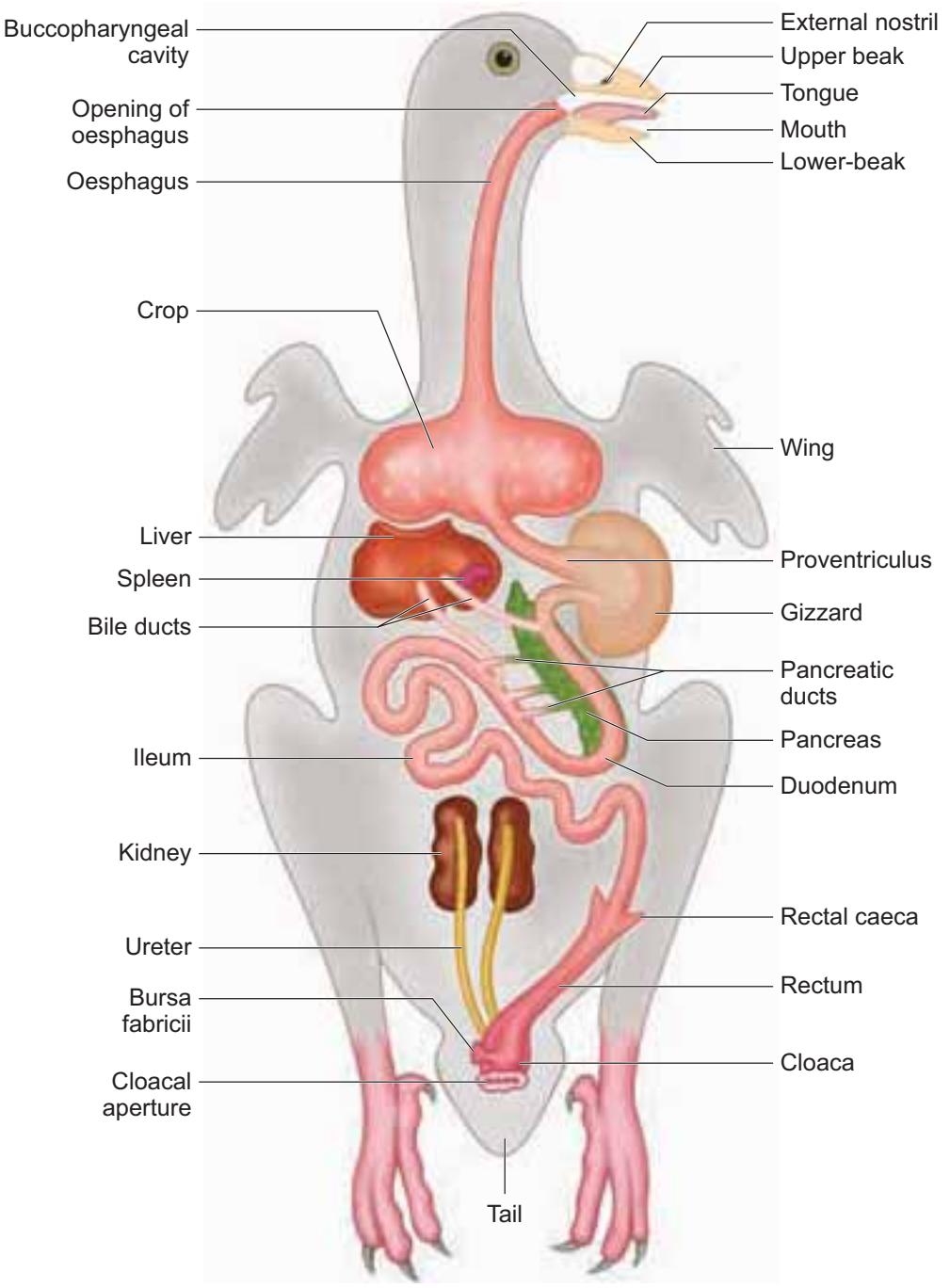


Figure 4.29 Pigeon – Digestive System

powerful flight muscle which arises from the sternum. Contraction of these muscles lower the wings in flight. Pectoralis minor (subclavius) is small and elongated muscle which elevates the wings during flight. Besides the pectoralis, the small **coracobrachialis** muscle also helps to pull the wings down and to rotate wings during flight.

Digestive System

The long coiled alimentary canal consist of buccal cavity, pharynx, oesophagus, crop, stomach, small intestine and Large intestine. (Figure 4.29)

Mouth is covered by a toothless, horny, upper and lower **beaks**. Behind the mouth, there is a wide buccal cavity. In the floor of the **buccal cavity**, a large, narrow, horny **tongue** is present with scanty **sensory papillae** and numerous **mucus glands**. Buccal cavity leads into the pharynx followed by the oesophagus, which enlarges to form a thin walled, bilobed elastic sac, the **crop**. The crop serves as a food reservoir. Beyond the crop the **oesophagus** enters the **stomach** which is differentiated into anterior glandular **proventriculus** and a posterior muscular **ventriculus** or **gizzard**. The proventriculus has a mucus lining which secretes the gastric juice. The walls of the gizzard is thick, muscular and has many tubular glands. The cavity of the gizzard contains grit or small pebbles called **gastroliths** that are swallowed by the bird. These stones helps the bird in grinding the food. The gizzard leads to a **small intestine** which consists of a 'U' shaped **duodenum** and **ileum**. The **pancreas** lies between the two limbs of the duodenum and receives three ducts from the pancreas and two bile ducts from the **liver**. The inner lining of the ileum contains numerous **villi** which helps in absorption. The ileum continues into the large intestine, which is short and is differentiated into rectum and cloaca. A pair of small blind pouches called **rectal caeca** is present at the junction of the ileum and rectum. The rectum leads into the **cloaca** which is divided into the anterior **coprodaeum** into which the rectum opens, the middle **urodaeum** into which the **urinigenital** ducts open, and the posterior **vestibule** or **proctodaeum**, which opens to the outside by the cloacal aperture.

Buccal glands, salivary glands, gastric glands, liver, pancreas and intestinal glands are the **digestive glands** which enhance the process of digestion in pigeon. There is **no gall bladder** in the pigeon though present in many other birds. Pigeons produce 'milk', a cheesy and nourishing secretion, from both the sexes. It is formed by the degeneration of the epithelial cells lining the crop. It is regurgitated and fed to the young birds.

The pigeon feeds on grains. As birds have no teeth, the food swallowed by it passes through the **gullet** or **oesophagus** into the **crop** where it is stored. There are mucous glands in the crop; food is softened by being mixed with the **mucus** and the secretion of the **buccal glands,** aided by the warmth of the body. The food then enters the **stomach,** where it is digested by **gastric juices** secreted in the **proventriculus**; the food is also **crushed** in the **gizzard** with aid of gastroliths. The food is thus reduced to smaller particles and the partly digested food passes into the **intestine** where it is

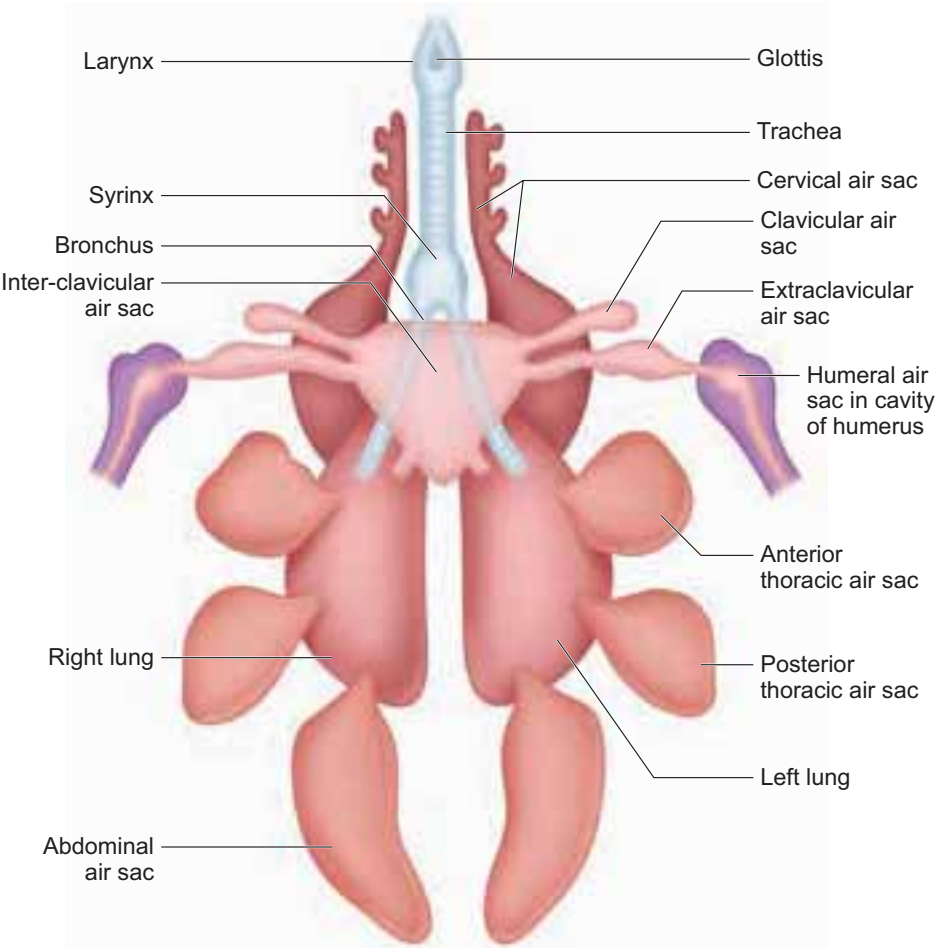


Figure 4.30 Pigeon – Respiratory System in ventral view

mixed with the **bile** and **pancreatic juice**, and further digestion is effected.

Respiratory system

In birds the type of respiration is **pulmonary.** The respiratory system includes the respiratory tract, the respiratory organs and air sacs. A true muscular diaphragm is absent in birds. The **respiratory tract** includes the nares, nasal sacs, glottis, larynx, trachea and syrinx. The **respiratory organs** are the lungs and air sacs. The larynx opens into the trachea and is supported by a series of closely set rings. The trachea divides into two **bronchi**, each of which divides and sub-divides into smaller branches, ultimately ending in fine air-capillaries which lies intermingled with the capillaries of the pulmonary vessels. Lungs are solid spongy organs; attached dorsally to the ribs. There are nine air-sacs: a pair of **cervical sacs** at the base of the neck one on each side; a single median **interclavicular air sac** connected with both lungs and situated in between the two limbs of the furcula and on either sides it gives off an **extraclavicular air sac** communicating with an air - cavity of the humerus and a **clavicular air sac**; two pairs of **thoracic air sacs** and a pair of **abdominal air sacs**. This complicated arrangement adds to the efficient respiratory function and maintenance of a high temperature (Figure 4.30).

Respiratory mechanism

The lungs are not dilatable since the skeleton around them forms a rigid framework. Inspiration is passive and expiration is an active process. During respiration the sternum

is drawn towards the vertebral column, by contraction of the muscles of the body-wall. As is drawn up, the elastic ribs are bent so as to bring about a decrease in the size of the body cavity and the air from the lungs is forced out. When the muscles relax, the body-cavity recovers its size and air is drawn in.

Syrinx

The larynx does not take part in the production of voice. The **voice box** lies deep down where the trachea divides into two bronchi, and is known as **syrinx**, a structure characteristic of birds. It consists of a chamber with its walls supported by three or four rings of the trachea and the first ring of each bronchus; its inner lining is raised into folds, the vibrations of which is caused by the movement of air results in the production of sound.

Circulatory system

Pigeon has an efficient circulatory system to meet the metabolic demands of flight, but also plays a significant role in maintaining the body temperature. The circulatory system of pigeon includes the heart and blood vessels. The **heart** of the pigeon is **four chambered** with two auricles and two ventricles. There is no sinus venosus. The two **precaval veins** or **superior venae cavae**, a **post caval vein** or **inferior vena cava** opens into the right auricle; the pulmonary aorta and systemic trunks arise from the right and left ventricles respectively. The right side of the heart is completely separated from the left side of the heart by a septum. The right auricle opens into the right ventricle by the **right auriculo-ventricular** aperture and the left auricle into the left ventricle by the **left auriculo- ventricular** aperture. There are **valves** at these apertures, which allows the blood to flow only in one direction, i.e., from the auricle into the ventricle but not backwards. The right auriculo-ventricular valve consists of a single flap without connecting **chordae tendinae**; the valve on the left side has two flaps connected to the **papillary muscles** by chordae tendinae. The pulmonary aorta arises from the right ventricle and the aortic arch from the left ventricle. The pulmonary veins open into the left auricle. There are three **semilunar valves** at the junction of the pulmonary aorta and the right ventricle. The pulmonary aorta divides into two branches, each entering a lung. Only the right aortic arch is present in birds.

The right auricles of the heart receives venous blood from all parts of the body except the lungs, through the **precaval** and **post caval** veins. The right ventricles pumps venous blood into the lungs through the **pulmonary aorta.** The oxygenated blood from the lungs is returned to the left auricle through the **pulmonary veins**. From the left ventricle a single right aortic arch carries oxygenated blood to the different parts of the body. The right half of the heart receives and discharges only **venous blood** and the left half only **arterial blood**. Thus birds possess a **complete double circulation** which includes the **pulmonary circulation** and **systemic circulation**. (Figure 4.31)

The arterial system

The right aortic arch curves over to the right side giving off at the curve the right and the left **innominate arteries**; each

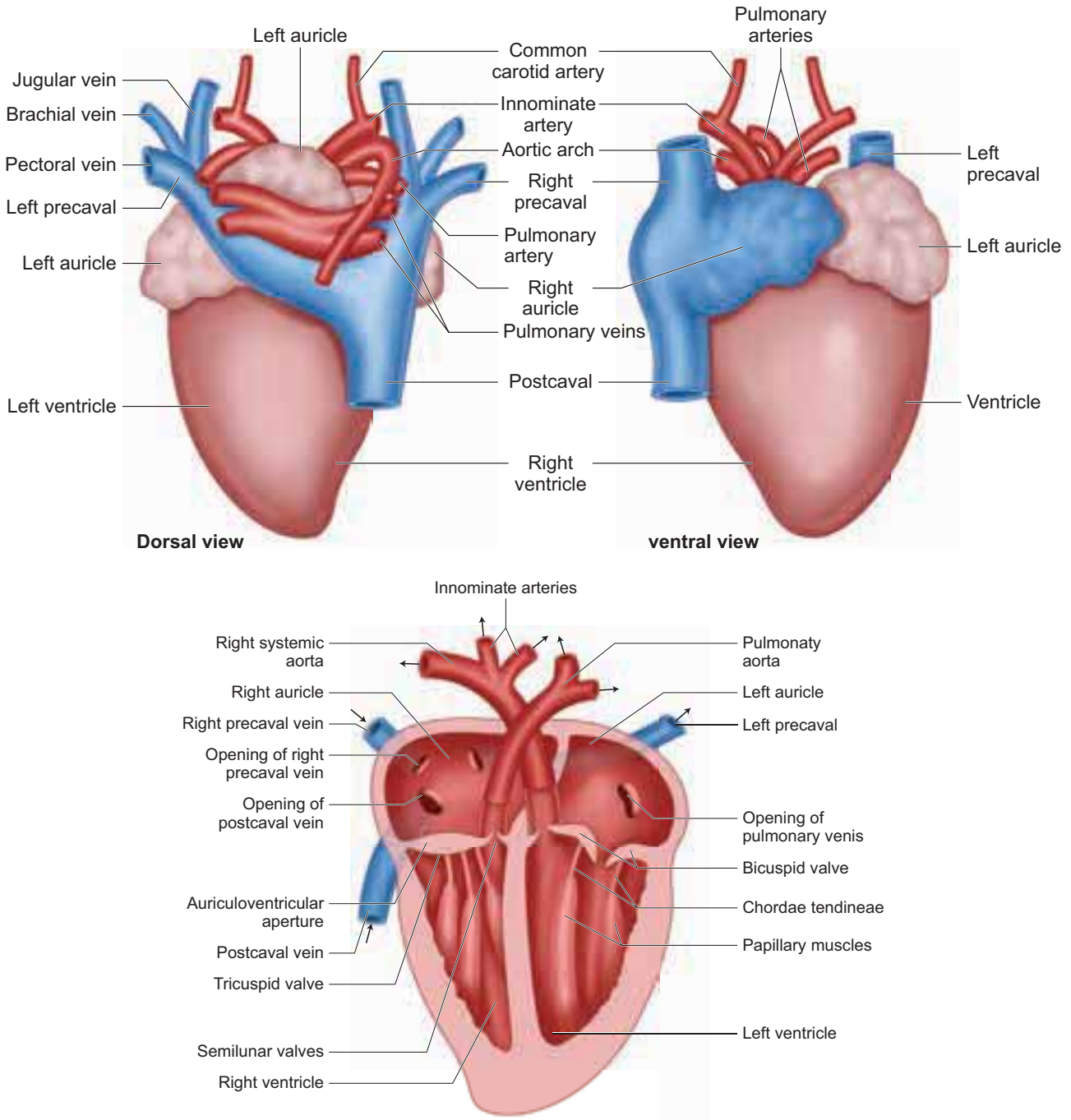


Figure 4.31 Pigeon. Structure of heart.

of these gives rise to a **carotid artery** and a **subclavian artery**, the former carrying blood to the brain. The subclavian artery divides into a **brachial artery** conveying blood to the arm, and a pectoral artery to the muscles of the wings. The aortic arch passes backwards as the dorsal aorta, from which are given off the unpaired **coeliac artery** supplying blood to the stomach, the liver and few parts of intestine; the unpaired **anterior mesenteric artery** to the great part of the intestine; the paired **anterior renal arteries** to the anterior lobes of the kidney; the paired **femoral arteries** supplying blood to the anterior region of the thigh and the paired **sciatic arteries** supply blood to the posterior parts of the thighs and the leg. From the each sciatic artery arises a **middle**

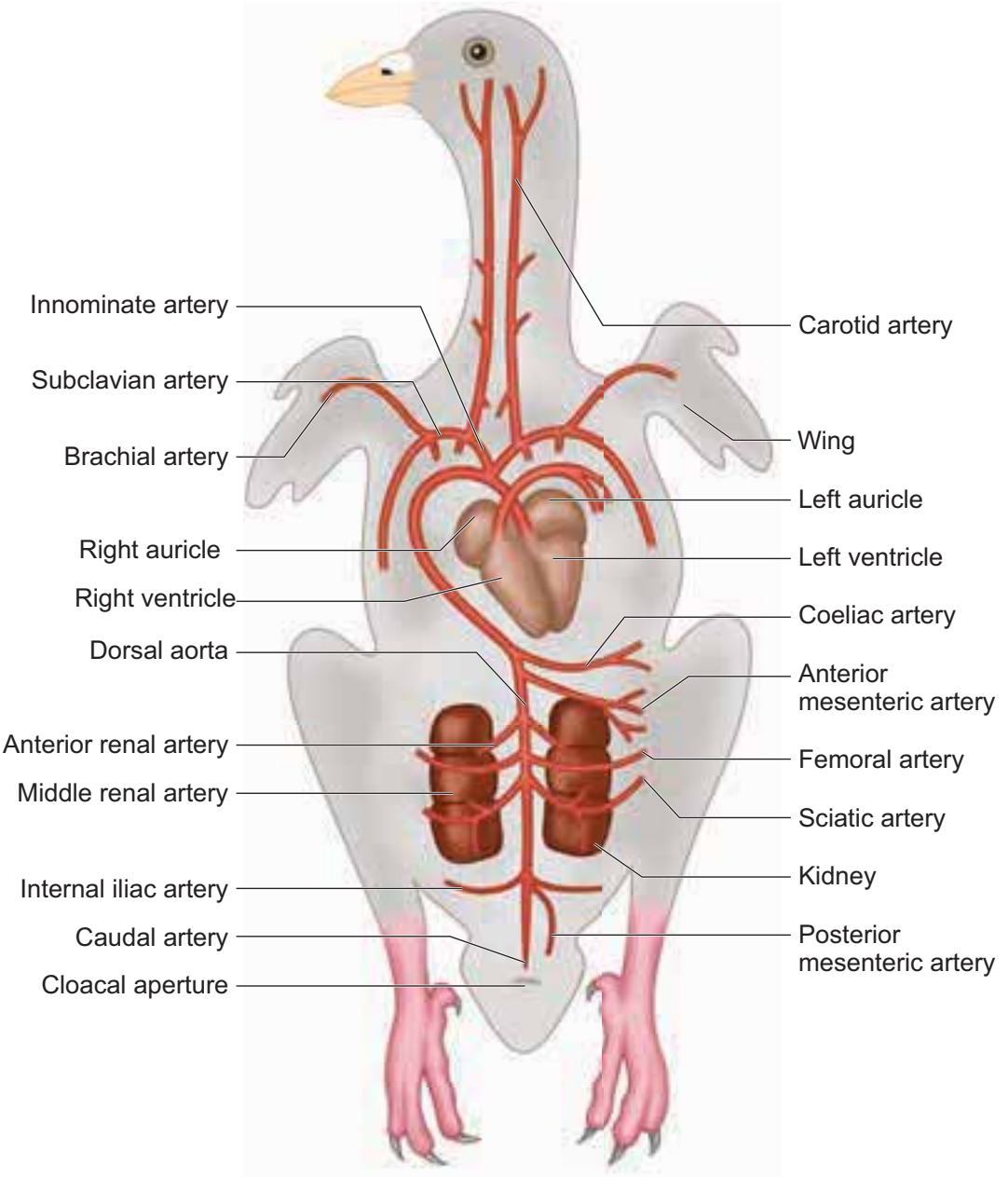


Figure 4.32 Pigeon. Arterial System

renal artery to the middle lobe of the kidney and a **posterior renal artery** to the posterior lobe; the unpaired posterior **mesenteric artery** supplies blood to the rectum and the cloaca; the paired **internal iliac arteries** to the pelvis and the **caudal artery** which is the terminal portion of the dorsal aorta extends to the tail (Figure 4.31).

The venous system

The **precaval vein** of each side is formed by the union of the **jugular vein** from the head, the **brachial vein** from the arm, and the **pectoral vein** from the pectoral muscles. The jugular vein of the two sides are connected in front by a transverse vessel. The **postcaval vein** is formed by the union of the two **iliac veins** in front of the kidney. Each iliac vein is in turn formed by the union of the **femoral vein** from the leg, an **efferent renal vein** from the kidney, and the renal-portal vein from the posterior regions. The hepatic-portal circulation is present and the blood from

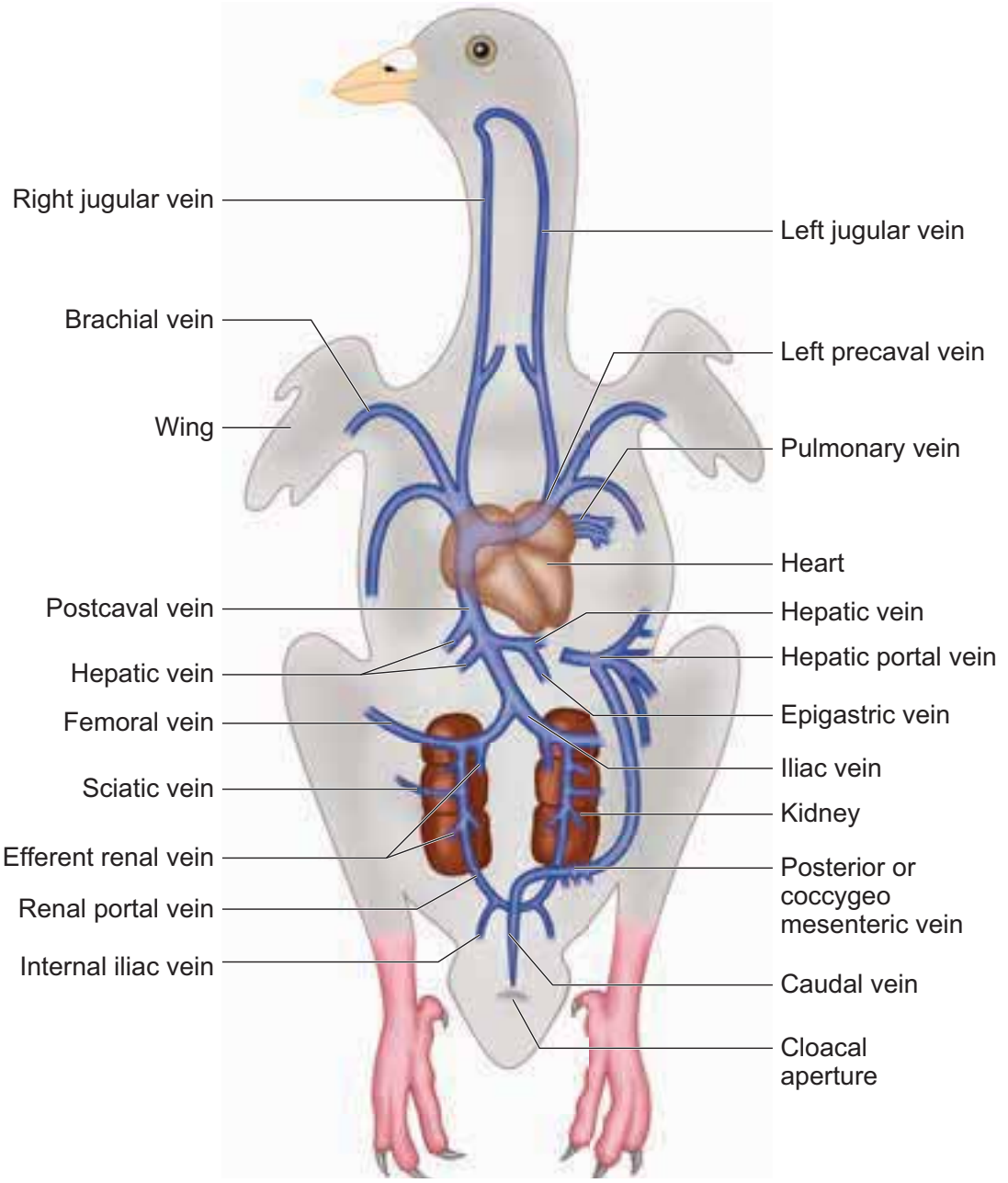


Figure 4.33 Pigeon – Venous System

the liver is emptied into the postcaval vein by three **hepatic veins.** (Figure 4.33)

The **caudal vein** from the tail divides into the right and the left renal-portal vein each of which enters the kidney. Before entry, the renal-portal vein is joined by the **internal iliac vein** from the pelvis. As the **renal-portal vein** passes through the kidney, it receives the sciatic and the femoral vein from the leg, and finally emerges from the kidneys as the iliac vein. The renal-portal veins do not break into capillaries in the kidney but only send a few small branches; renal-portal circulation is therefore not well developed in the bird.

At the place of bifurcation of the caudal vein into the two renal-portal veins arises the median **coccygeomesenteric vein** which is characteristic of birds.

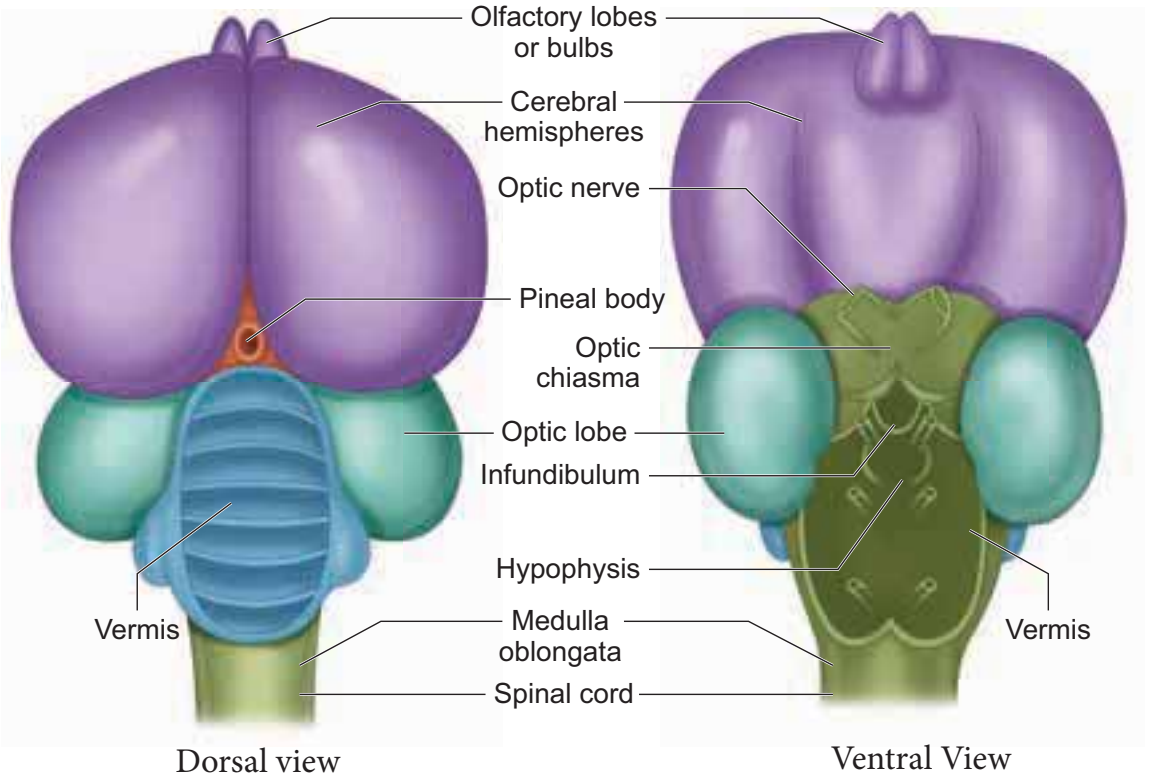


Figure 4.34 Pigeon - Structure of brain

This vein runs forward, receives in its course veins from the rectum, and joins the **hepatic portal vein.** The **epigastric vein** returns the blood from the mesenteries and joins one of the hepatic veins.

Nervous system and receptor organs

The nervous system consists of **central nervous system** which includes the brain and spinal cord, the **peripheral nervous system** and the **autonomous nervous system** (Figure 4.34). The brain of pigeon is larger than in lower forms, it is short, broad and rounded within cranial cavity. It is covered by two **meninges**, the outer **duramater** and an inner **pia- arachnoid** membrane and the space between the two meninges is filled with **cerebrospinal fluid**. The **cerebral hemispheres** of the pigeon are large and extend behind to meet the **cerebellum**. The cerebrum controls voluntary movements and is the centre for memory and intelligence. The **diencephalon** is covered dorsally by the cerebral hemispheres and cerebellum. The diencephalon relays impulses to the cerebral hemispheres, integrates the **autonomic system** and the perception of extreme cold, pain, heat etc. On the ventral side of the diencephalon is the **optic chiasma,** behind the chiasma projects the **infundibulum** bearing a large **hypophysis** or **pituitary**. The optic lobes are large and occupy a lateral position owing to the large size of the cerebral hemispheres and cerebellum. Optic lobes are centres for sight. The pineal body and infundibulum are present. The cerebellum is highly developed and convoluted indicating the delicate sense of equilibrium and the great power of muscular co-ordination required for birds.

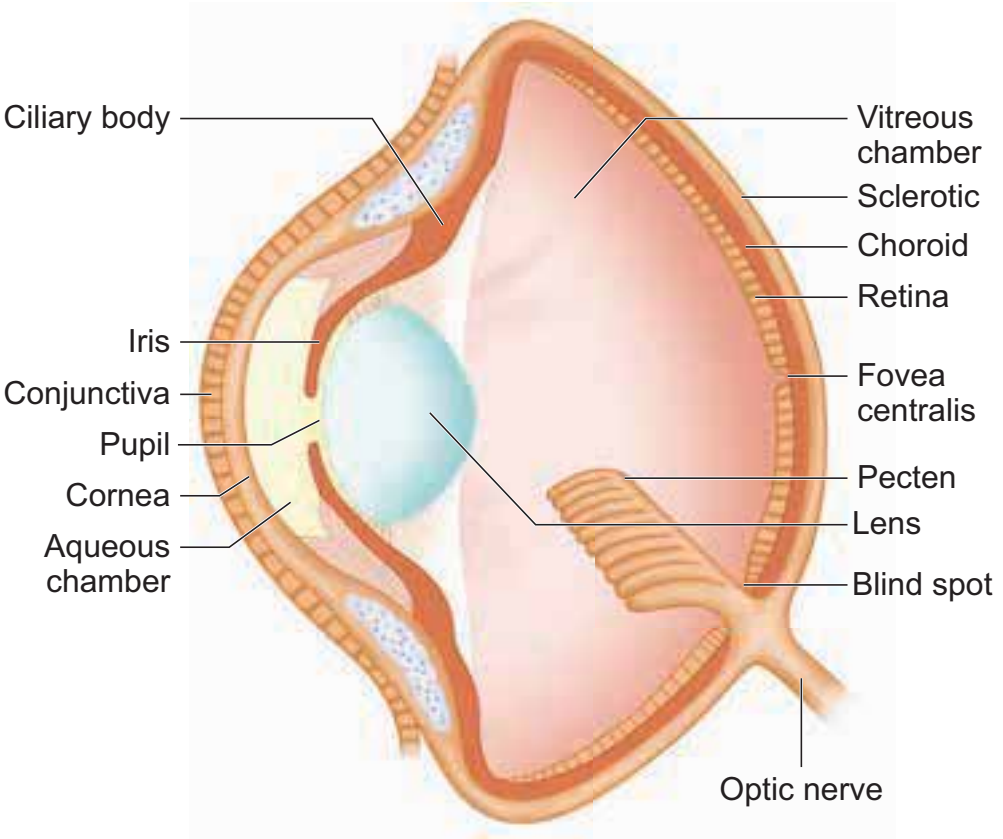


Figure 4.35 Pigeon – Eye in Vertical Section (VS)

The cerebellum extends backwards covering a large part of the medulla oblongata which descends downwards to join the **spinal cord.** The medulla oblongata controls the involuntary movement. The olfactory lobes or bulbs are small and degenerate due to poorly developed organs of smell.

The peripheral nervous system consists of 12 pairs of **cranial nerves** and 38 pairs of **spinal nerves**. The autonomic nervous system of pigeon includes the **sympathetic** and **parasympathetic** nervous system. It contains the nerves and ganglia. The sympathetic nerves supply the alimentary, respiratory, circulatory and urinogenital systems.

In Pigeon what part of its brain will you relate with its remarkable ability to discriminate between cancerous and non cancerous images ?

Sense organs

Eyes are large and well developed; they are not spherical, but biconvex. The sclerotic coat contains bony plates. There is a vascular pigmented plaited process known as the **pecten,** projecting into the **vitreous body** from the point where the optic nerve enters the eye (Figure 4.35). Pecten is concerned with the power of accommodation which is greatly developed in birds. The muscles for the movement of the eye-balls are reduced. In the **ear,** the **cochlea** is well developed. The two **eustachian tubes** unite and open by a common aperture on the roof of the buccal cavity. The **olfactory** sense is poorly developed.

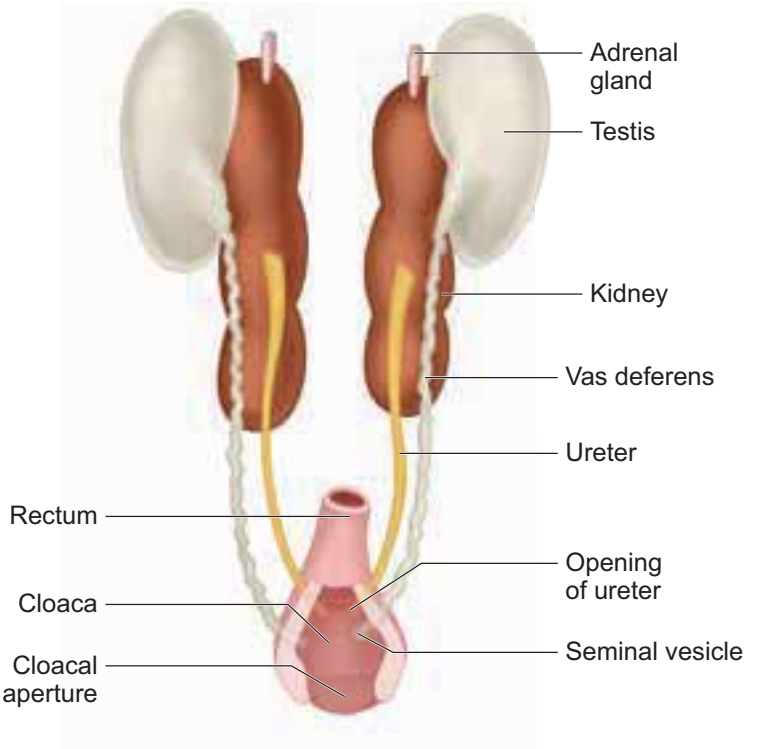


Figure 4.36 Pigeon –Male Urinogenital System

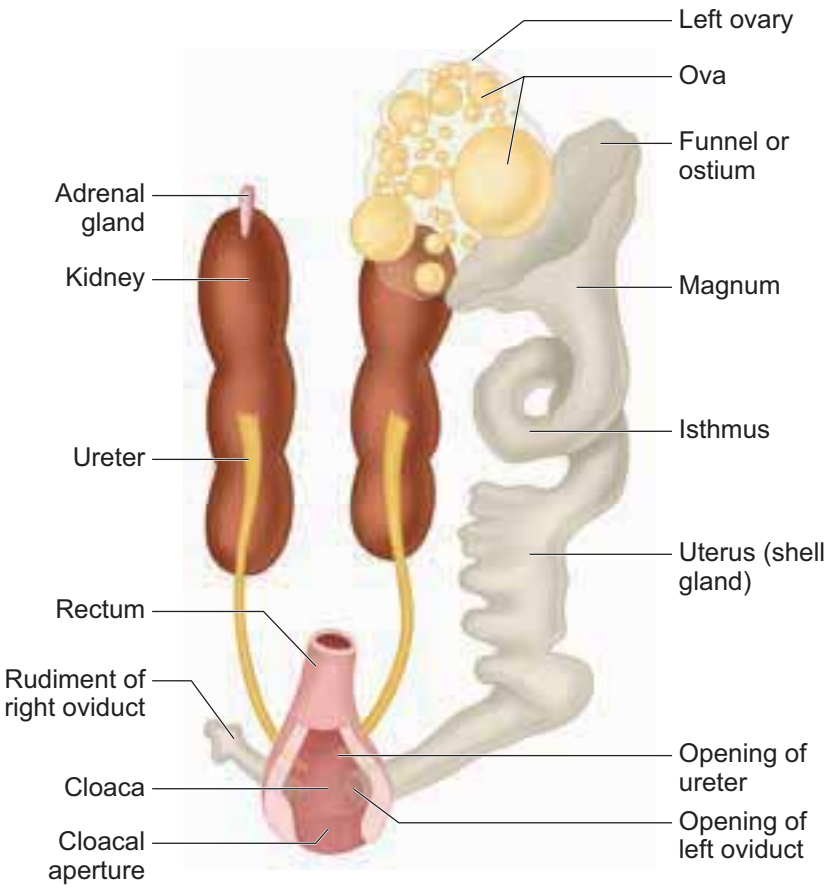


Figure 4.37 Pigeon –Female Urinogenital System

Effects of Pesticides on Birds Egg

DDT is a pesticide that was widely used on crops until the 1970s. DDT was banned in several countries because of the harm it was causing to birds. DDT causes some birds to produce thin egg shells, decreasing the survival rates of birds' offsprings. This resulted in decreasing population of several species. The thinning of the eggs was so significant that even the weight of an incubating bird could crush the eggs. With the ban of DDT in some countries, populations of the birds have increased.

Urinogenital system

Excretory System

The paired kidneys which are **metanephric** are flat, elongated and lobulated. The ureters lead directly backward to open into the **urodaeum** or middle compartment of the cloaca; there is no urinary bladder. The nitrogenenous waste is excreted in the form of uric acid and discharged as a semi-solid mass. **Adrenal bodies** lie attached to the ventral surface of the kidneys as small yellowish elongated streaks.

Reproductive system.

A pair of ovoid **testes** are attached to anterior end of the kidneys by peritoneum (Figure 4.36). From each testis leads the **vas deferens** which runs backwards along the outer side of the ureter of that side, and opens on a small papilla into the urodaeum. The vas deferens is dilated into a **seminal vesicle** at its hind end. There is no copulatory organ.

The **female reproductive organs** consist of a single **ovary** on the left side which is an **adaptation** to aerial life and an oviduct which opens into the body-cavity by a funnel-like aperture at the anterior end and posteriorly opens into the **urodaeum** (Figure 4.37).

DO YOU KNOW?

Pigeons can be trained to distinguish identities and emotional expressions on human faces, letters of the alphabet, misshapen pharmaceutical capsules, and even paintings. Pigeons are sensitive to diagnostically salient features in medical images such as slides and x-rays to diagnose and classify disease risk. When trained, pigeons can correctly identify, distinguish normal and cancerous digitized slides and X rays. Pigeons are remarkably adept at discriminating between benign and malignant breast cancer slides at all magnification.

Activity 1

1 Examine a quill feather. Hold the base of the central shaft with one hand and gently bend the tip of the feather with your other hand. Be careful not to break the feather. Next, hold the shaft and wave the feather in the air. Record your observations concerning the structure of the quill feather. Relate your observations to the feather's possible function. Describe the function of the feather under "Function of feather" in your data table.

2 Examine the vane of the feather. Does the vane appear to be a solid structure? Include a description of the quill feather's vane structure under "Structure of feather" in your data table.

3 Make a drawing of the quill feather. Label the shaft, vanes and barbs. Compare your diagram with the feather.

Activity 2

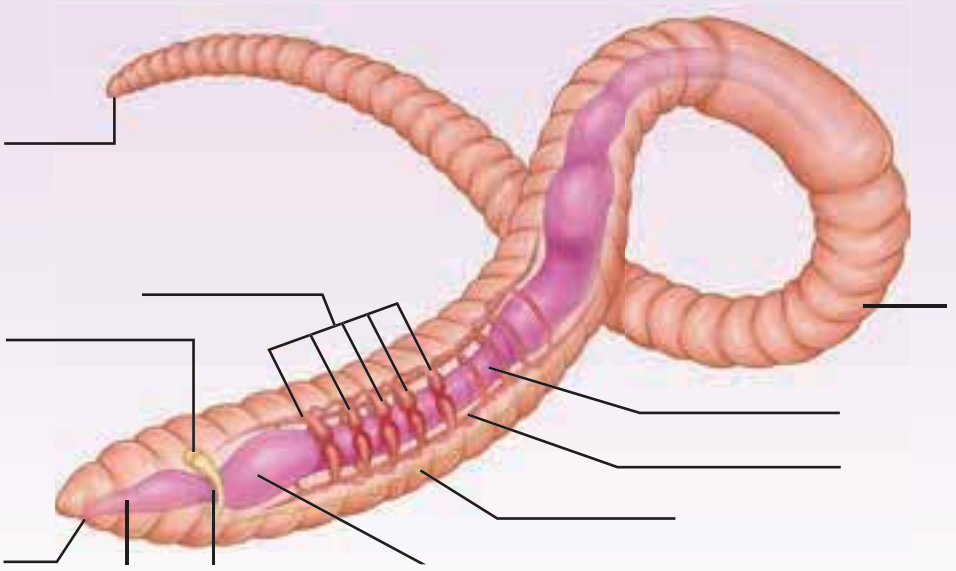
Students are divided into groups of three or four and given an earthworm on a damp paper towel. The paper towel should be placed in container so that the worms do not move away. For two minutes, students should observe the worm and record its behavior and morphology. Identify the earthworm's anterior, posterior ends and its external apertures and locate the earthworm's clitellum. Using a battery torch, focus light on the earthworm and observe whether the earthworm moves towards light or away from light. Why? This will be recorded on their lab sheet under "Worm's behaviour and morphology." Students can then watch a short video of an earthworm dissection where the different organs of the worm are labelled and explained. Ask the students to label the different parts of the worm and its anatomy after watching the video. At the end of the lab work, students may be asked to recall about the parts of the worm's body responsible for regulating, signalling, and performing its behaviour.

Earthworm dissection video

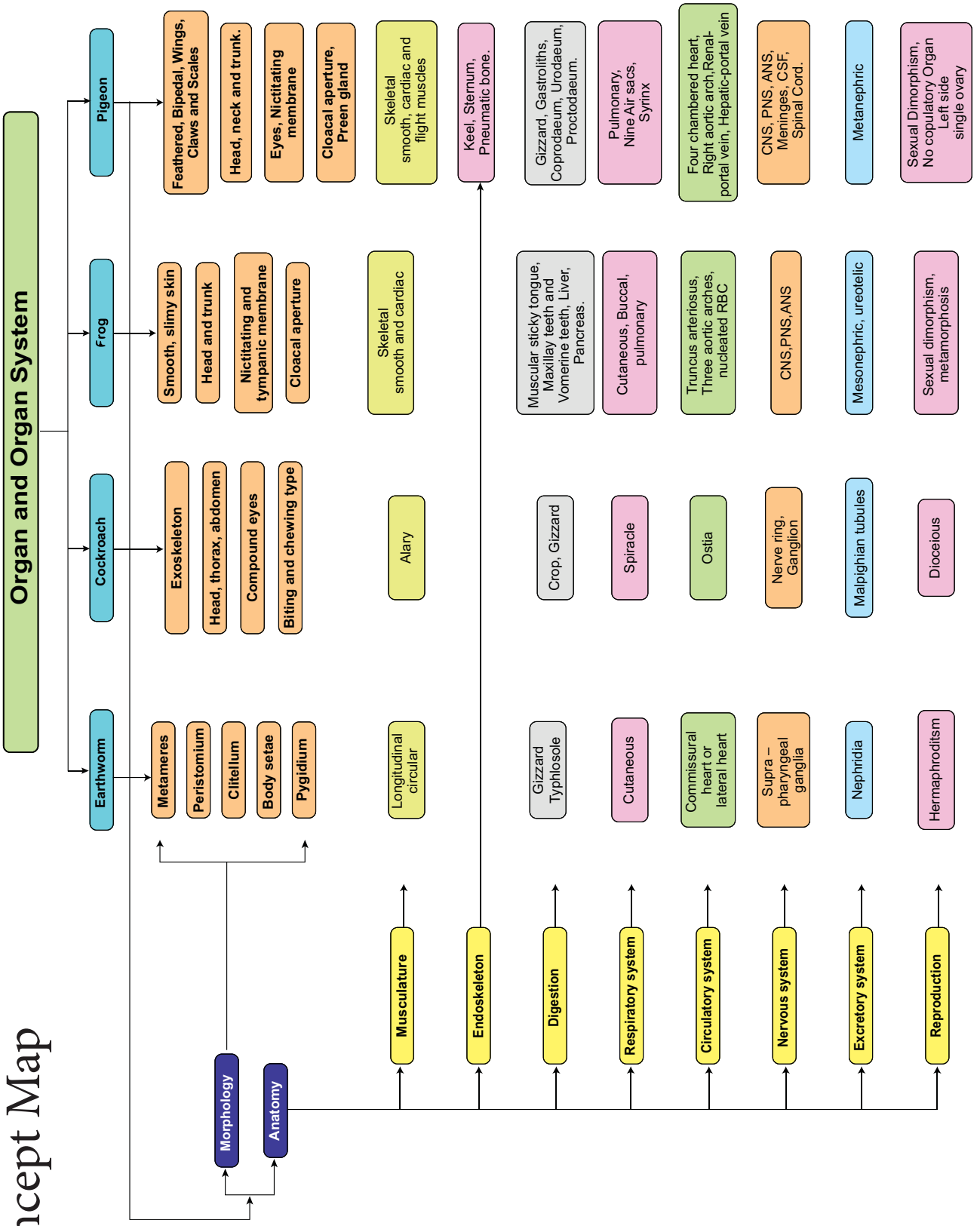
http://www.youtube.com/watch?v=A2BY 0hRUA9E

In the given diagram using the terms given below, label the parts of the worm:

Mouth, Anus, Brain, Crop, Gizzard, Intestine, Pharynx, Segments, Clitellum, Blood vessels, Hearts, Oesophagus, and Nerve Cord.



Concept Map



SUMMARY

Earthworm, Cockroach and Frog show characteristic features in body organization. *Lampito mauritii* (earthworm) is commonly found in Tamil Nadu, its body is covered by cuticle. It has a long and cylindrical narrow body which is bilaterally symmetrical. All segments of its body are alike except the 14 to 17 segments, which are thick and dark and glandular, forming the clitellum. This helps in the formation of cocoons. A ring of S-shaped chitinous setae is found in each segment. These setae help in locomotion. Earthworm's development is direct and no larva is formed during development.

Cockroach is a typical cosmopolitan insect and exhibits all the fundamental characteristics of class Insecta. The body of the cockroach is compressed dorso-ventrally, bilaterally symmetrical, segmented and divisible into three distinct regions – head, thorax and Abdomen. The photoreceptor organ of the cockroach consists of a pair of compound eyes with mosaic vision. Segments bear jointed appendages. There are three throacic segments of each bearing a pair of walking legs. Two pairs of wings are present, one pair each on 2nd and 3rd segment. There are ten segments in abdomen. Fertilization is internal. The development of cockroach is gradual through nymphal stages (paurometabolus).

Frogs are cold blooded vertebrates – Poikilotherms. Skin is smooth and moist, Red blood corpuscles are nucleated. Eggs are laid in water. The larvae pass through an aquatic stage before metamorphosing into adult.

Birds are warm blooded, bipedal vertebrates. They have an exoskeleton of feathers. Their forelimbs are modified into wings to aid in aerial mode of life

Glossary

After-shaft – Small tuft of soft feathers near the superior umbilicus of Quill feather

Articular membrane – The non-sclerotized, flexible membrane between the segments of arthropods, and the joints of arthropod appendages.

Bipedal – Walk or stand on two feet.

Buccal cavity – The first region of the alimentary canal, between mouth and pharynx.

Chloragogen Cells – Surrounding the alimentary canal; is attributed to excretion and regeneration.

Clitellum – A regional epidermal swelling, where gland cells secrete material to form the cocoon.

Cochlea – A coiled tube found in the inner ear, essential for hearing

Cocoon – It is a bag like structure secreted by the clitellum. Eggs and sperms are deposited into it. Fertilization and development occurs within the cocoon.

Coelom – The body cavity between the body wall and the alimentary canal.

Cutaneous Respiration – Respiration through skin

Elytra – Elytra (singular elytron) are the tough forewings of beetles and earwigs. The

elytra are not used in flight but are used to protect the more delicate hind wings. The elytra are often coloured or decorated with pits and grooves

Gizzard – The muscularized portion of the digestive system.

Homeothermic – Warm blooded and maintain a constant body temperature.

Hypopharynx – The hypopharynx is a somewhat globular structure, located medially to the mandibles and the maxillae. In many species it is membranous and associated with salivary glands. It assists in swallowing the food.

Labium – A fused mouthpart which forms the floor of the mouth of an insect. The labium is the most complex of the cockroach mouthparts.

Mandibles – Insect mandibles are a pair of appendages near the insect's mouth, and the most anterior of the three pairs of oral appendages (the labrum is more anterior, but is a single fused structure). Their function is typically to grasp, crush, or cut the insect's food, or to defend against predators or rivals.

Maxillae – In arthropods, the maxillae (singular maxilla) are paired structures present on the head as mouthparts in members of the clade Mandibulata, used for tasting and manipulating food.

Maxillary teeth – In frog a row of small and pointed maxillary teeth is found on the inner region of the upper jaw.

Nephridia – They are highly coiled excretory organs.

Nestlings – The young birds' that has not left the nest.

Nictitating membrane – A transparent membrane drawn over and protect the eye when frog is under water

Nuptial pad – Copulatory pad which is present only in male frog

Oviparous – Oviparous animals are animals that lay eggs, with little or no other embryonic development within the mother.

Poikilotherms – Cold blooded organisms/ Body temperature fluctuates according to environmental temperature

Sclerites – Sclerite is hard armor like structure for arthopods (even cockroaches) soft body. Sclerites are really deposition of Calcium or cross linking of protein to make the exoskeleton stronger.

Setae – They are small, S- Shaped chitinous structures present in the pits of the body wall of earthworms. They aid is locomotion. Some setae are modified into Penial setae in the male genital opening and these help in copulation.

Sinus venosus – A large thin walled, triangular chamber, which is present on the dorsal side of the heart.

Tympanum – The vibrating ear drum involved in hearing

Typhlosole – A median dorsal internal fold in the intestine of several types of animals, including the earthworm,

Vectors –**A** vector is an organism that does not cause disease itself but which spreads

infection by conveying pathogens from one host to another.

Villus – A minute finger-like process from intestinal lining of vertebrates

Vocal sac – The male frog has a pair of vocal sacs a little behind the mouth. They assist in amplifying the croaking sounds of frog.

Evaluation

1. The clitellum is a distinct part in the body of earthworm *Lampito mauritii*, it is found in?
   a. Segments 13 - 14
   b. Segments 14 - 17
   c. Segments 12 - 13
   d. Segments 14 - 16
2. Sexually, earthworms are
   a. Sexes are separate
   b. Hermaphroditic but not self - fertilizing
   c. Hermaphroditic and self – fertilizing
   d. Parthenogenic
3. To sustain themselves, earthworms must guide their way through the soil using their powerful muscles. They gather nutrients by ingesting organic matter and soil, absorbing what they need into their bodies. True or False: The two ends of the earthworm can equally ingest soil.
   a. True b. False
4. The head region of Cockroach _____ pairs of _____ and _____ shaped eyes occur.
   a. One pair, sessile compound and kidney shaped
   b. Two pairs, stalked compound and round shaped
   c. Many pairs, sessile simple and kidney shaped
   d. Many pairs, stalked compound and kidney shaped
5. The location and numbers of malpighian tubules in *Periplaneta*.
   a. At the junction of midgut and hindgut, about 150.
   b. At the junction of foregut and midgut, about 150.
   c. Surrounding gizzard, eight.
   d. At the junction of colon and rectum, eight.
6. The type of vision in Cockroach is _____
   a. Three dimensional
   b. Two dimensional
   c. Mosaic
   d. Cockroach do not have vision
7. How many abdominal segments are present in male and female Cockroaches?
   a. 10, 10 b. 9, 10
   c. 8, 10 d. 9, 9
8. Which of the following does not have an open circulatory system?
   a. Frog b. Earthworm
   c. Pigeon d. Cockroach
9. Buccopharyngeal respiration in frog
   a. is increased when nostrils are closed
   b. Stops when there is pulmonary respiration
   c. is increased when it is catching fly
   d. stops when mouth is opened.

10. Kidney of frog is
    a. Archinephros
    b. Pronephros
    c. Mesonephros
    d. Metanephros
11. Presence of gills in the tadpole of frog indicates that
    a. fishes were amphibious in the past
    b. fishes involved from frog -like ancestors
    c. frogs will have gills in future
    d. frogs evolved from gilled ancestor
12. Choose the wrong statement among the following:
    a. In earthworm, a single male genital pore is present.
    b. Setae help in locomotion of earthworms.
    c. Muscular layer in the body wall of earthworm is made up of only circular muscles.
    d. Typhlosole is part of the intestine of earthworm.
13. Which of the following are the sense organs of Cockroach?
    a. Antennae, compound eyes, maxillary palps, anal cerci
    b. Antennae, compound eye, maxillary palps
    c. Antennae, ommatidia, maxillary palps, sternum
    d. Antennae, eyes, maxillary palps, and tarsus of walking legs
14. Pneumatic bone is found in
    a. Shark b. Rana
    c. Pigeon d. Whale
15. What is the function of the preen gland?
    a. produce digestive enzymes.
    b. To release scents that help attract mates.
    c. To control salt balance in the body.
    d. To produce an oil substance used to condition the feathers.
16. Quill feathers at the base of quill wings are called
    a. Coverts b. Remiges
    c. Down feathers d. Barbules.
17. Excretory waste of birds and reptitles are
    a. Urea
    b. Ammonia
    c. Uric acid
    d. Ammonia and uric acid.
18. Which of the following is an adaptation to the aerial mode of life in Pigeon
    a. Single ovary on the left side
    b. Pair of ovary on both the side
    c. Single ovary on the right side
    d. Both (a) and (c)
19. What characteristics are used to identify the earthworms?
20. What are earthworm casts?
21. How do earthworms breathe?
22. Why do you call cockroach a pest?
23. Comment on the functions of alary muscles?
24. Name the visual units of the compound eyes of cockroach.
25. How does the male frog attracts the female for mating?
26. Write the types of respiration seen in frog.

27. Differentiate between peristomium and prostomium in earthworm.
28. Give the location of clitellum and spermathecal openings in *Lampito mauritii.*
29. Differentiate between tergum and a sternum.
30. Head of cockroach is called hypognathous. Why?
31. What are the components of blood in frog?
32. Draw a neat labeled diagram of the digestives system of frog.
33. Explain the reproductive system of frog
34. List the characteristics features of Pigeon.
35. Distinguish between vanes, barbs and barbules.
36. Explain the reproductive system of frog
37. Comment on the role of air sacs in increasing the respiratory efficiency in birds.

References

1. Ekambaranatha Ayyar, Anantha Krishnan, 5th Edition- (1987); Manual of Zoology, Vol I Invertebrata - S.Viswanathan Publishers and Printers Pvt. Ltd.,
2. Ekambaranatha Ayyar, Anantha Krishnan, 5th Edition- (1987); Manual of Zoology, Vol II Chordata –S.Viswanathan Publishers and Printers Pvt. Ltd.,
3. Jordan E. L, Verman P. S, Revised Edition- (2009); Invertebrate Zoology, S. Chand & Company Ltd.,
4. Kotpal R. L , (2012), Modern text book of Zoology; Vertebrates [Diversity – II] – 3rd Edition; Rastogi Publications.
5. John H. Postlethwait and Janet L. Hopson ; Holt, Rinehart and Winston, Modern Biology; A Harcourt Education Company, Orlando. Austin. NewYork. San Diego. Toronto. London.
6. Sultan Ismail, A (1992), The Earthworm Book, Other India Press, India.

UNIT III Chapter 5

Digestion and Absorption

Obtaining and utilizing nutrients is a fundamental process in all living organisms.

Chapter Outline

Learning Objectives:

- *Identifies and explains the major parts of the alimentary canal and digestive glands.*
- *Learns the process of digestion in various parts of the alimentary canal.*
- *Understands the role of enzymes in the process of digestion.*
- *Learns the symptoms of digestive disorders.*
- *Learns the role of nutrients in energy production, body building and maintenance and regulation of body activities.*
- *Creates awareness about the nutritional disorders and alimentary canal disorders.*

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We all eat food. If you do not take breakfast in the morning how do you feel by noon? The food we eat provides energy and organic substances for growth and for replacement of worn and damaged tissues. It also regulates and coordinates the various activities that take place in our body. The components of our food are carbohydrates, proteins, lipids, vitamins, minerals, fibre and water. We obtain food from plant and animal sources. The food, we eat are macromolecules, and cannot directly enter into our cells. These have to be broken into smaller micromolecules in absorbable forms, for which we need a digestive system. Plants however are autotrophs and synthesize their food, hence they do not require a digestive system. The primary function of the digestive system in the animals is to bring

the nutrients, water and electrolytes from the external environment into every cell in the body through the circulatory system.

Alimentary canal faces a conflict between the need of nutrient absorption and to keep our intestinal tract free from pathogenic bacteria and virus. About 7 litres of digestive juice are poured into the alimentary canal and are reabsorbed each day. If this does not happen the body gets rapidly dehydrated and may lead to reduction in the blood pressure.

5.1. Digestive system

The process of digestion involves intake of the food (Ingestion), breakdown of the food into micromolecules (Digestion), absorption of these molecules into the blood stream (Absorption), the absorbed substances becoming components of cells (Assimilation) and elimination of the undigested substances (Egestion). Digestive system includes the alimentary canal and associated digestive glands.

5.1.1. Structure of the alimentary canal

The alimentary canal is a continuous, muscular digestive tract that begins with an anterior opening, the mouth and opens out posteriorly through the anus. The alimentary canal consists of mouth, buccal cavity, pharynx, oesophagus, stomach, intestine, rectum and anus (Figure. 5.1). The mouth is concerned with the reception of food and leads to the buccal cavity or oral cavity (Figure. 5.2). Mechanical digestion is initiated in the buccal cavity by chewing with the help of teeth and tongue. Chemical digestion is through salivary enzymes secreted by the salivary glands.

Each tooth is embedded in a socket in the jaw bone; this type of attachment is called **thecodont**. Human beings and many mammals form two sets of teeth during their life time, a set of 20 temporary milk teeth (deciduous teeth) which gets replaced by a set of 32 permanent teeth (adult teeth). This type of dentition is called **diphyodont**. The permanent teeth are of four different types (**heterodont**), namely, Incisors (I) chisel like cutting teeth, Canines (C) dagger shaped tearing teeth, Pre molars (PM) for grinding, and Molars (M) for grinding and crushing. Arrangement of teeth in each half of the upper and lower jaw, in the order of I, C, PM and M can be represented by a dental formula, in human the dental formula is 2123/2123.

Mineral salts like calcium and magnesium are deposited on the teeth and form a hard layer of **'tartar' or calculus** called plaque. If the plaque formed on teeth is not removed regularly, it would spread down the tooth into the narrow gap between the gums and enamel and causes inflammation, called **gingivitis**, which leads to redness and bleeding of the gums and to bad smell. The hard chewing surface of the teeth is made of enamel and helps in mastication of food.

Tongue is a freely movable muscular organ attached at the posterior end by the frenulum to the floor of the buccal cavity and is free in the front. It acts as a universal tooth brush and helps in intake

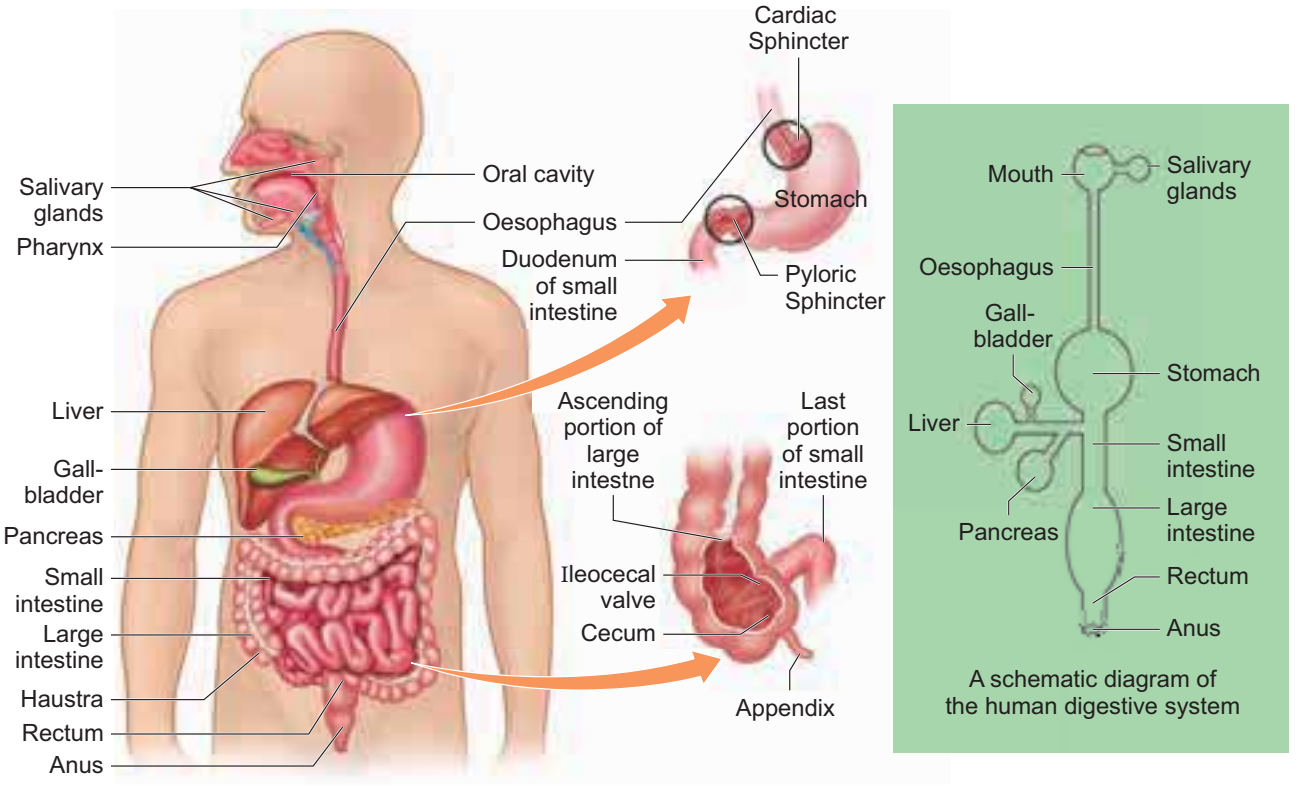

Figure 5.1 The Human Digestive system

food, chew and mix food with saliva, to swallow food and also to speak. The upper surface of the tongue has small projections called papillae with taste buds.

The oral cavity leads into a short common passage for food and air called pharynx. The oesophagus and the trachea (wind pipe) open into the pharynx. Food passes into the oesophagus through a wide opening called gullet at the back of the pharynx. A cartilaginous flap called epiglottis prevents the entry of food into the glottis (opening of trachea) during swallowing. Two masses of lymphoid tissue called tonsils are also located at the sides of the pharynx.

Oesophagus is a thin long muscular tube concerned with conduction of the food to a 'J' shaped stomach passing through the neck, thorax and diaphragm. A cardiac sphincter (gastro oesphageal sphincter) regulates the opening of oesophagus into the stomach (Figure. 5.1). If the cardiac sphincter does not contract properly during the churning action of the stomach the gastric juice with acid may flow back into the oesophagus and cause heart burn, resulting in **GERD** (Gastero Oesophagus Reflex Disorder).

The stomach functions as the temporary storage organ for food and is located in the upper left portion of the abdominal cavity. It consists of three parts – a cardiac portion into which the oesophagus opens; a fundic portion and a pyloric portion that opens into the duodenum. The opening of the stomach into the duodenum is guarded by the pyloric sphincter. It periodically allows partially digested food to enter the duodenum and also prevents regurgitation of food. The inner wall of stomach has many folds called **gastric rugae** which unfolds to accommodate a large meal.

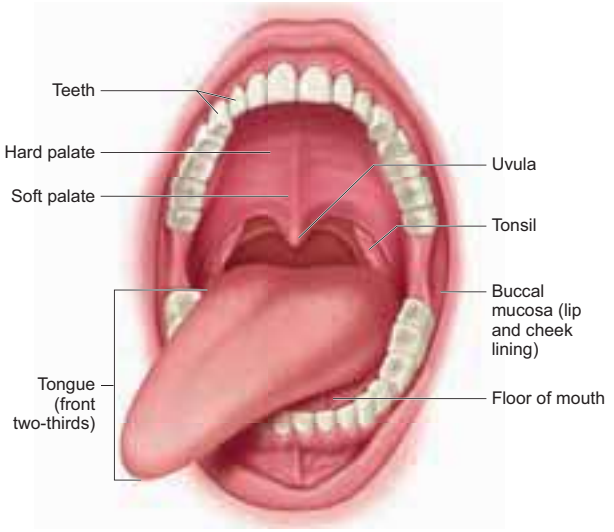

Figure 5.2 Buccal cavity

The small intestine assists in the final digestion and absorption of food. It is the longest part of the alimentary canal and has three regions, a 'U' shaped duodenum (25cm long), a long coiled middle portion jejunum (2.4m long) and a highly coiled ileum (3.5m long). The wall of the duodenum has Brunner's glands which secrete mucus and enzymes. Ileum is the longest part of the small intestine and opens into the caecum of the large intestine. The ileal mucosa has numerous vascular projections called villi which are involved in the process of absorption and the cells lining the villi produce numerous microscopic projections called microvilli giving a brush border appearance that increase the surface area enormously. Along with villi, the ileal mucosa also contain mucus secreting goblet cells and lymphoid tissue known as **Peyer's patches** which produce lymphocytes. The wall of the small intestine bears crypts between the base of villi called **crypts of Leiberkuhn** (Figure.5.3).

The large intestine consists of caecum, colon and rectum. The caecum is a small blind pouch like structure that opens into the colon and it possesses a narrow finger like tubular projection called **vermiform appendix**. Both caecum and vermiform appendix are large in herbivorous animal and act as an important site for cellulose

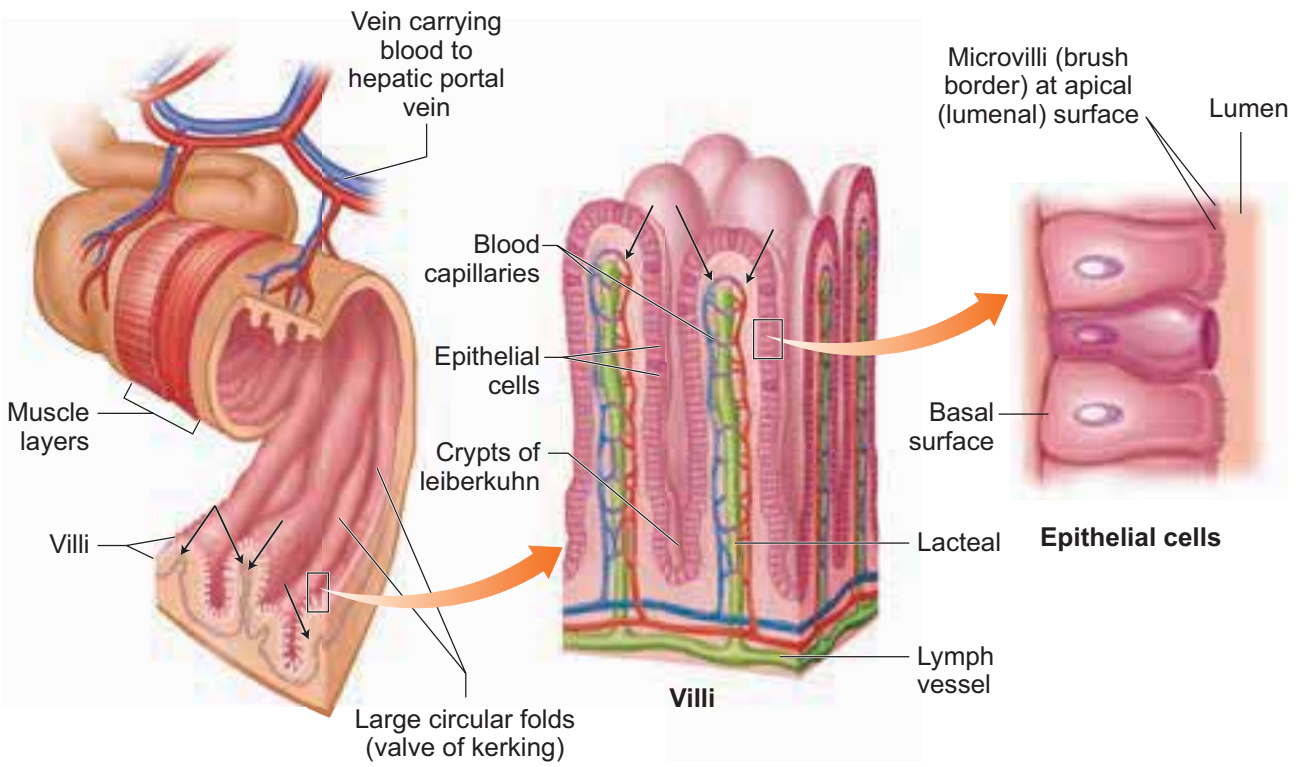

Figure 5.3 Small intestine with Villi

digestion with the help of symbiotic bacteria. The colon is divided into four regions – an ascending, a transverse, a descending part and a sigmoid colon. The colon is lined by dilations called **haustra** (singular – haustrum) (Figure.5.4). The "S" shaped sigmoid colon (pelvic colon) opens into the rectum. Rectum is concerned with temporary storage of faeces. The rectum open out through the anus. The anus is guarded by two anal sphincter muscles. The anal mucosa is folded into several vertical folds and contains arteries and veins called anal columns. Anal column may get enlarged and causes **piles** or **haemorrhoids**.

5.1.2 Histology of the Gut

The wall of the alimentary canal from oesophagus to rectum consists of four layers (Figure 5.5) namely serosa, muscularis, sub-mucosa and mucosa. The serosa (visceral peritoneum) is

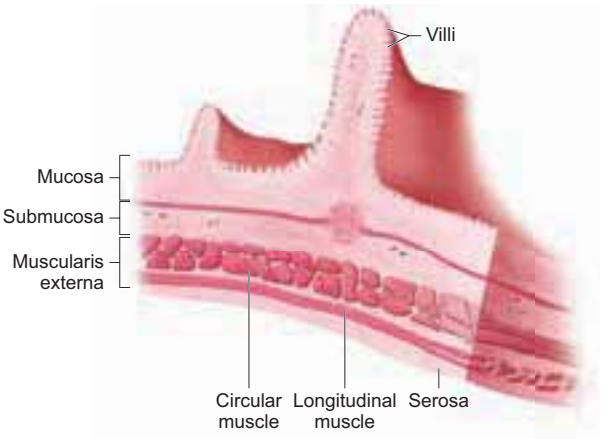

Figure 5.5 The layers of the alimentary canal

the outermost layer and is made up of thin squamous epithelium with some connective tissues. Muscularis is made of smooth circular and longitudinal muscle fibres with a network of nerve cells and parasympathetic nerve fibres which controls peristalsis. The submucosal layer is formed of loose connective tissue containing nerves, blood, lymph vessels and the sympathetic nerve fibres that control the secretions of intestinal juice.

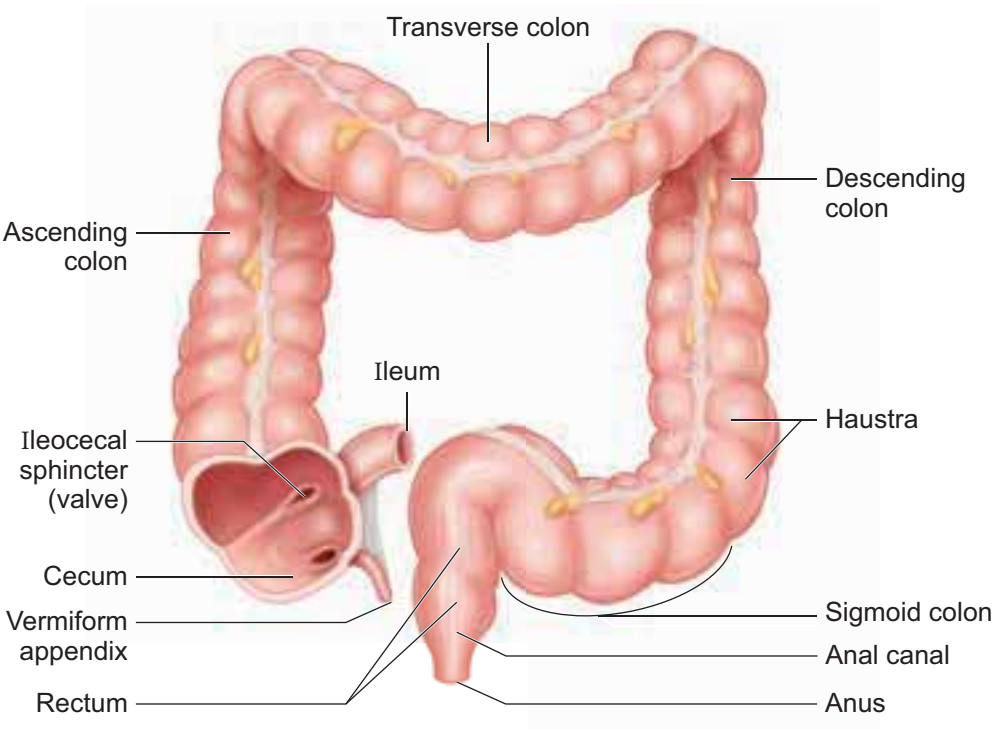

Figure 5.4 Large intestine

The innermost layer lining the lumen of the alimentary canal is the mucosa which secretes mucous.

Though the bile juice of liver has no digestive enzyme but is very essential for proper digestion of food, especially of the fats. Discuss the following?

a) What is composition of bile?

b) How it helps in digestion of fats and other nutrients of food?

c) How it helps in absorption of fats?

5.1.3 Digestive glands

Digestive glands are exocrine glands which secrete biological catalysts called enzymes. The digestive glands associated with the alimentary canal are salivary glands, liver and pancreas. Stomach wall has gastric glands that secrete gastric juice and the intestinal mucosa secretes intestinal juice.

Salivary glands

There are three pairs of salivary glands in the mouth. They are the largest parotids gland in the cheeks, the sub-maxillary/ sub-mandibular in the lower jaw and the sublingual beneath the tongue. These glands have ducts such as **Stenson's duct, Wharton's duct and Bartholin's duct or duct of Rivinis** respectively (Figure. 5.6). The salivary juice secreated by the salivary glands reaches the mouth through these ducts. The daily secretion of saliva from salivary glands ranges from 1000 to 1500mL.

Gastric glands

The wall of the stomach is lined by gastric glands. Chief cells or **peptic cells or zymogen cells** in the gastric glands secrete gastric enzymes and **Goblet cells** secrete mucus. The **Parietal or oxyntic cells** secrete HCl and an intrinsic factor responsible for the absorption of Vitamin B_{12} called Castle's intrinsic factor.

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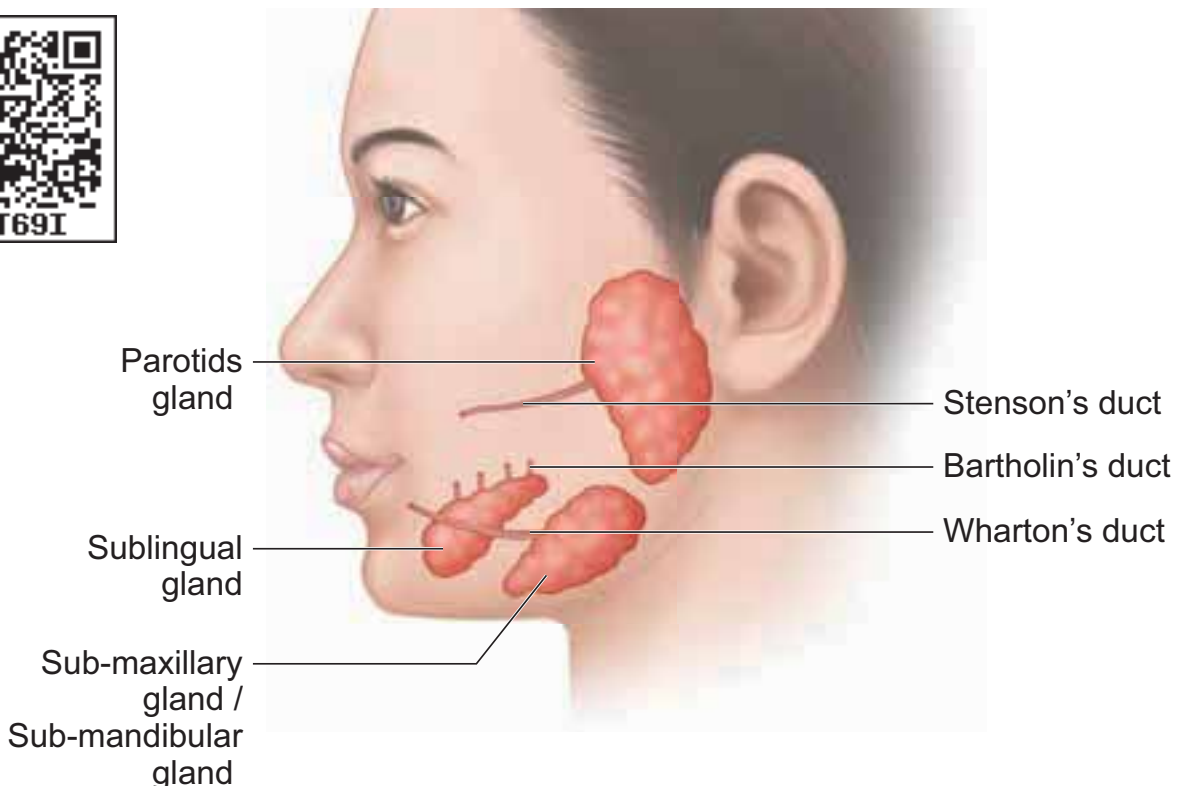


Figure 5.6 Salivary glands

Liver

The liver, the largest gland in our body is situated in the upper right side of the abdominal cavity, just below the diaphragm. The liver consists of two major left and right lobes; and two minor lobes. These lobes are connected with diaphragm. Each lobe has many hepatic lobules (functional unit of liver) and is covered by a thin connective tissue sheath called the **Glisson's capsule**. Liver cells (hepatic cells) secrete bile which is stored and concentrated in a thin muscular sac called the gall bladder. The duct of gall bladder (cystic duct) along with the hepatic duct from the liver forms the common bile duct. The bile duct passes downwards and joins with the main pancreatic duct to form a common duct called hepato-pancreatic duct. The opening of the hepato-pancreatic duct into the duodenum is guarded by a sphincter called the **sphincter of Oddi** (Figure.5.7). Liver has high power of regeneration and liver cells are replaced by new ones every 3-4 weeks.

Apart from bile secretion, the liver also performs several functions

1. Destroys aging and defective blood cells
2. Stores glucose in the form of glycogen or disperses glucose into the blood stream with the help of pancreatic hormones
3. Stores fat soluble vitamins and iron
4. Detoxifies toxic substances.
5. Involves in the synthesis of non-essential amino acids and urea.

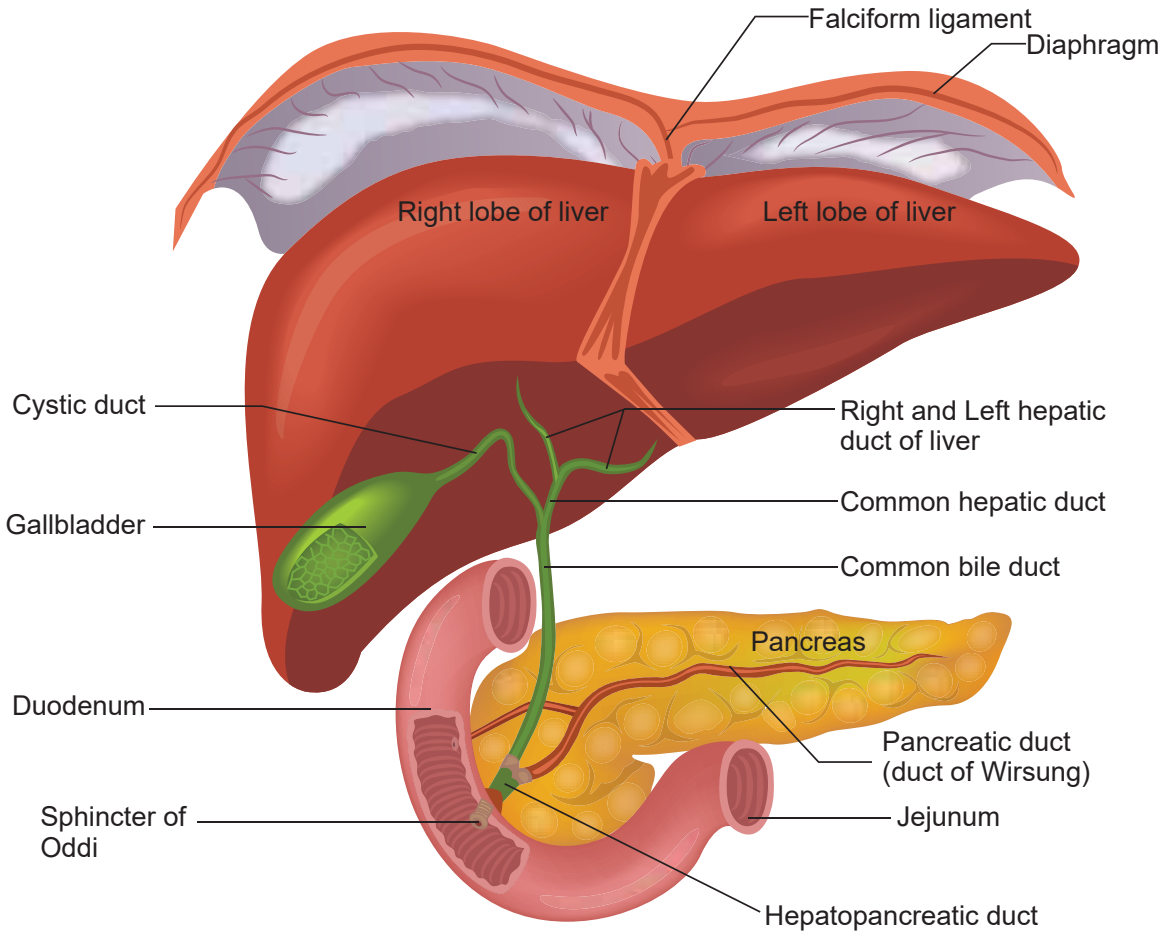


Figure 5.7 Liver and pancreas

List the chemical preservatives, artificial enhancers found in the food items available in the market. How can you avoid such harmful substances in your food?

Pancreas

The second largest gland in the digestive system is the Pancreas, which is a yellow coloured, compound elongated organ consisting of exocrine and endocrine cells. It is situated between the limbs of the 'U' shaped duodenum. The exocrine portion secretes pancreatic juice containing enzymes such as pancreatic amylase, trypsin and pancreatic lipase and the endocrine part called Islets of Langerhans secretes hormones such as insulin and glucagon. The pancreatic duct directly opens into the duodenum.

5.2 Digestion of food and role of digestive enzymes

The process of digestion converts the solid food into absorbable and assimilable forms. This is accomplished by mechanical and chemical processes.

Digestion in the buccal cavity

The smell, sight and taste as well as the mechanical stimulation of food in the mouth, triggers a reflex action which results in the secretion of saliva. The mechanical digestion starts in the mouth by grinding and chewing of food. It is called mastication. The saliva contain water, electrolytes (Na^+, K^+, Cl^-, HCO_3), salivary amylase (ptyalin), antibacterial agent lysozyme and a lubricating agent mucus (a glycoprotein). The mucus in saliva prepares the food for swallowing by moistening, softening, lubricating and adhering the masticated food into a bolus. About 30 percent of polysaccharide, starch is hydrolyzed by the salivary amylase enzyme into disaccharides (maltose). The **bolus** is then passed into the pharynx and then into the oesophagus by swallowing or **deglutition**. The bolus further passes down through the oesophagus to the stomach by successive waves of muscular contraction called peristalsis. The gastro oesphageal sphincter controls the passage of food into the stomach.

Digestion in the stomach

Food remains in the stomach for 4 to 5 hours, the rhythmic peristaltic movement churns and mixes the food with gastric juice and make it into a creamy liquid called **chyme**. The gastric secretion is partly controlled by autonomic reflexes. The secretion of gastric juice begins when the food is in the mouth. The gastric juice contains HCl and proenzymes. The proenzyme pepsinogen, on exposure to HCl gets converted into the active enzyme pepsin which converts proteins into proteoses and peptones (peptides). The HCl provides an acidic medium (pH1.8) which is optimum for pepsin, kills bacteria and other harmful organisms and avoids putrifaction. The mucus and bicarbonates present in the gastric juice play an important role in lubrication and protection of the mucosal epithelium from the eroding nature of the highly acidic HCl (Figure. 5.8). Another proteolytic enzyme found in gastric juice of infants is rennin helps in the digestion

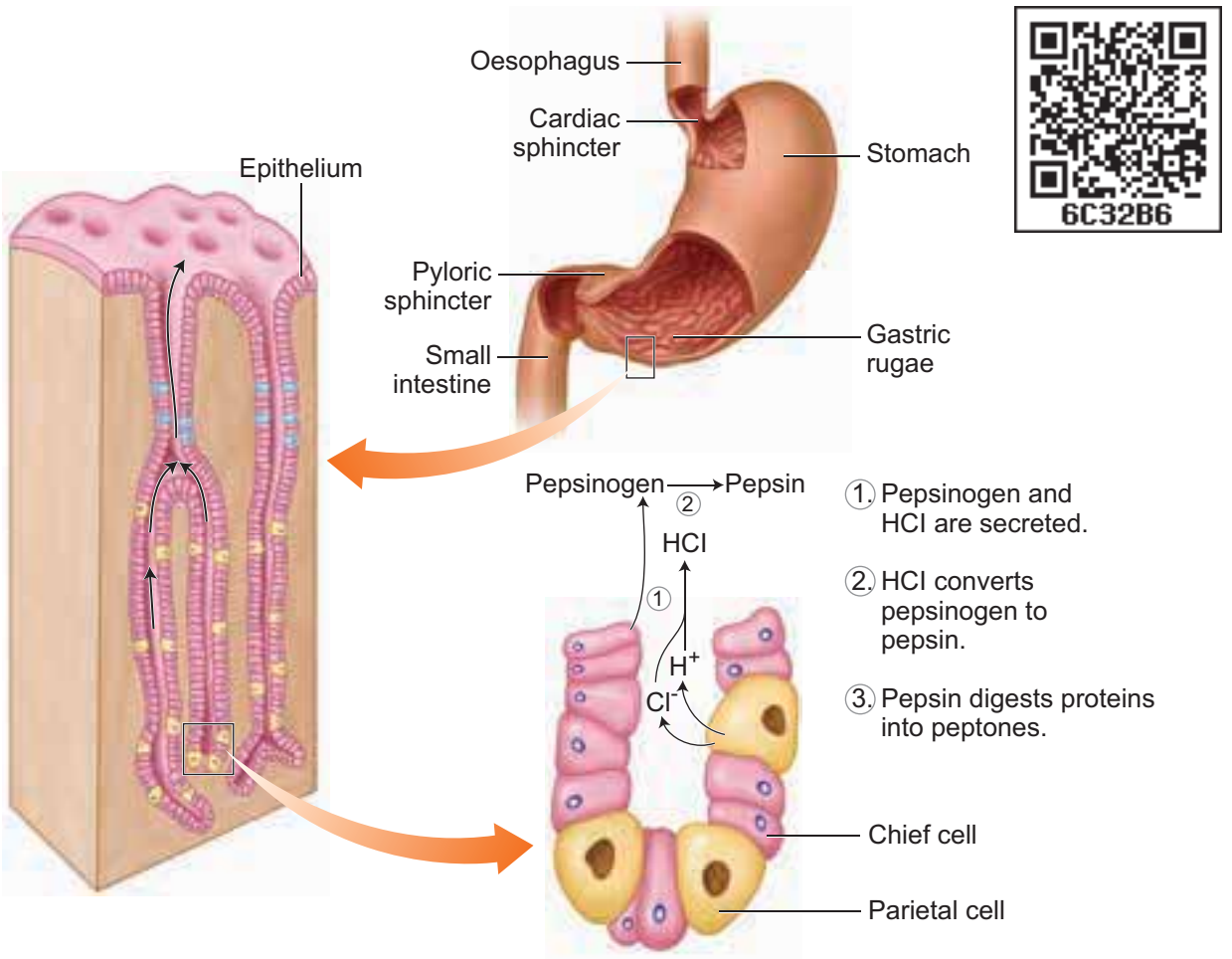


Figure.5.8. The stomach and gastric secretions

Bicarbonates in the saliva make the pH 5.4 to 7.4. If the bicarbonates level in saliva is reduced the saliva becomes acidic and the tooth enamel may get dissolved.

of milk protein, caseinogen to casein in the presence of calcium ions. This enzyme secretion gradually reduces with aging.

Digestion in the small intestine

The bile, pancreatic juice and intestinal juice are the secretions released into the small intestine. Movements generated by the muscularis layer of the small intestine

What would happen if HCl is not secreted in the stomach?

helps in the thorough mixing of the food with various secretions in the intestine and thereby facilitate digestion.

The pancreatic juice contains enzymes such as trypsinogen, chymotrypsinogen, carboxypeptidases, pancreatic amalyses, pancreatic lipases and nucleases. Trypsinogen is activated by an enzyme, enterokinase, secreted by the intestinal mucosa into active trypsin, which in turn activates the enzyme chymotrypsinogen in the pancreatic juice. The bile contains bile pigments (bilirubin and biliverdin) as the break down products of hemoglobin

of dead RBCs, bile salts, cholesterol and phospholipids but has no enzymes. Bile helps in emulsification of fats. Bile salts reduce the surface tension of fat droplets and break them into small globules. Bile also activates lipases to digest lipids.

Proteins and partially digested proteins in the chyme on reaching the intestine are acted upon by the proteolytic enzymes of pancreatic juice. Trypsin hydrolyses proteins into polypeptides and peptones, while chymotrypsin hydrolyses peptide bonds associated with specific amino acids.

The pancreatic amylase converts glycogen and starch into maltose. Lipase acts on emulsified fat (triglycerides) and hydrolyses them into free fatty acid and monoglycerides. Monoglycerides are further hydrolysed to fatty acid and glycerol. Nucleases in the pancreatic juice break the nucleic acid into nucleotides and nucleosides.

The secretions of the Brunner's gland along with the secretions of the intestinal glands constitute the intestinal juice or **succus entericus**. The enzymes in the intestinal juice such as maltase, lactase, sucrase (invertase), dipeptidases, lipases, nucleosidases act on the breakdown products of bile and pancreatic digestion.

Maltose $\xrightarrow{\text{Maltase}}$ glucose + glucose

Sucrose $\xrightarrow{\text{sucrase}}$ glucose + fructose

Lactose $\xrightarrow{\text{Lactase}}$ glucose + galactose

Dipeptides, Tripeptides $\xrightarrow{\text{Peptidase}}$ amino acids

Nucleotides $\xrightarrow{\text{Nucleotidase}}$ Nucleoside + Phosphoric acid

Nucleoside $\xrightarrow{\text{Nucleosidase}}$ Sugar + Nitrogen base

Diglycerides and monoglycerides $\xrightarrow{\text{Lipases}}$ Fatty acids + glycerol

The mucus along with the bicarbonate ions from the pancreas provides an alkaline medium (pH 7.8) for the enzymatic action. As a result of digestion, all macromolecules of food are converted into their corresponding monomeric units.

Carbohydrates $\longrightarrow$ monosaccharides (glucose, fructose, galactose)

Proteins $\longrightarrow$ amino acids

Lipids $\longrightarrow$ fatty acids and glycerol

The simple substances thus formed are absorbed in the jejunum and ileum region of the small intestine. The undigested and unabsorbed substances are propelled into the large intestine. The activities of the gastro-intestinal tract are carried out by the neural and hormonal control for proper

Do you feel ill after drinking milk or after eating dairy products?

If so, you cannot digest disaccharide lactose in milk because, the intestinal enzyme lactase is either inactive or absent or present only in very small amounts. The undigested lactose remains in the gut in such persons with lactose intolerance and is broken down by bacteria, causing gas, bloating, stomach cramps and diarrhoea.

coordination of different parts. Gastric and intestinal secretions are stimulated by neural signals. Hormonal control of the secretion of digestive juices is carried out by local hormones produced by the gastric and intestinal mucosa.

5.3 Absorption and assimilation of proteins, carbohydrates and fats

Absorption is a process by which the end product of digestion passes through the intestinal mucosa into the blood and lymph. The villi in the lumen of ileum are the absorbing units, consisting of a lacteal duct in the middle surrounded by fine network of blood capillaries. The process of absorption involves active, passive and facilitated transport. Small amounts of glucose, amino acids and electrolytes like chloride ions are generally absorbed by simple diffusion. The passage of these substances into the blood depends upon concentration gradients. However, some of the substances like fructose are absorbed with the help of the carrier ions like Na+. This mechanism is called facilitated transport.

Nutrients like amino acids, glucose and electrolytes like Na^+ are absorbed into the blood against the concentration gradient by active transport. The insoluble substances like fatty acids, glycerol and fat soluble vitamins are first incorporated into small, spherical water soluble droplets called micelles and are absorbed into the intestinal mucosa where they are re-synthesized into protein coated fat globules called

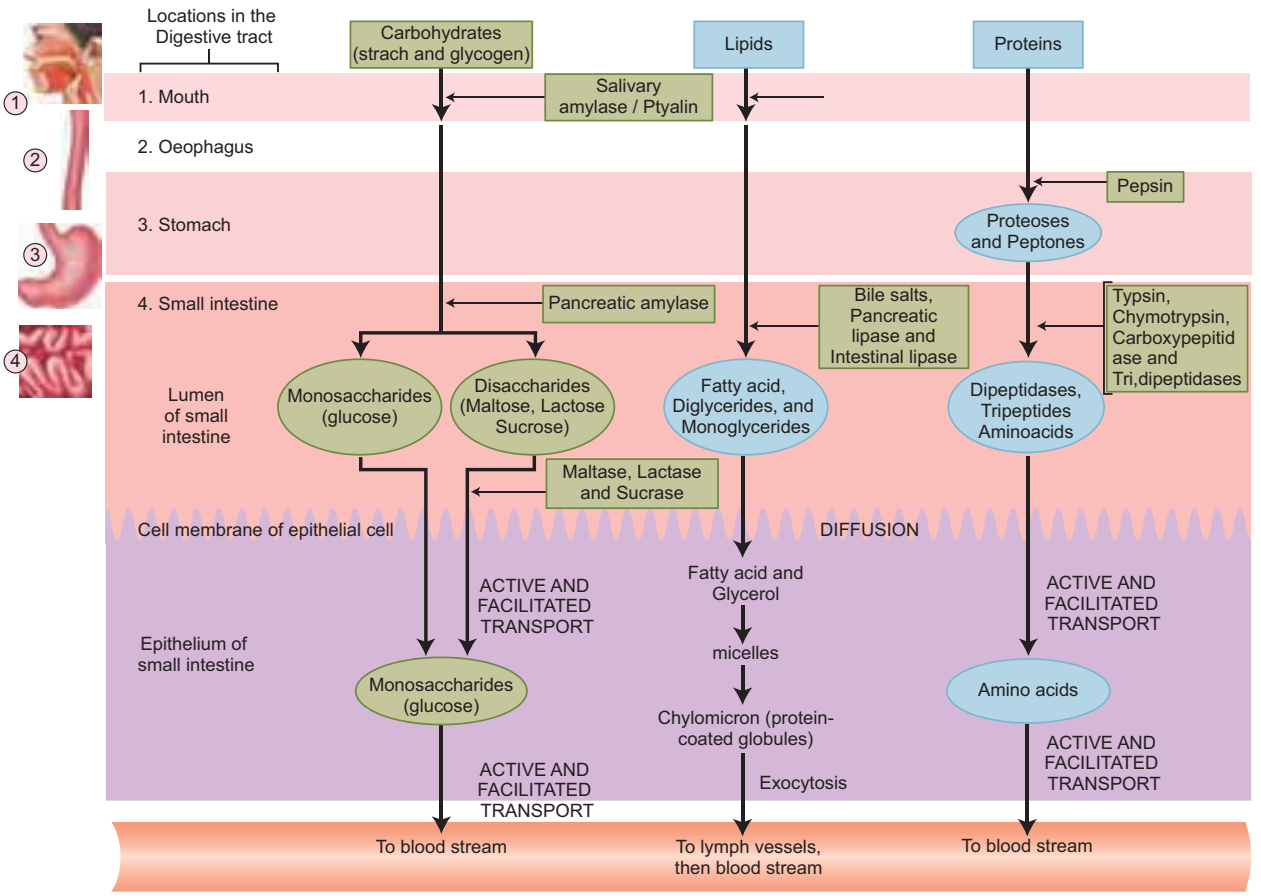


Figure 5.9 Process of Digestion and absorption

The human digestive system is pretty amazing.

Turning the food we eat into fuel the body uses for energy and to help us grow. However sometimes even small changes in our everyday routine can get in the way of healthy digestion.

Do you know? Digestive system associated disorders are gastritas, bloating, diarrhoea, constipation, heartburn and acid reflux, jaundice, gall stones obesity, etc...

1 Digestion begins as soon as food enters into the mouth.

2 Oesophagus:

The oesophagus is a tube connecting the mouth to the stomach. After swallow, the food travels down through the esophagus to the stomach.

Do you know? The oesophagus takes your chewed food and squeezes it downward using muscle contractions called peristalasis.

5 Liver:

The liver secrete bile. Bile helps the small intestine by breaking downs fats and making them easier to absorb.

6 Gall bladder stores bile secretion.

Do you know? The liver is also an important detoxification organ. It helps to filter and elimate harmful toxins from our body.

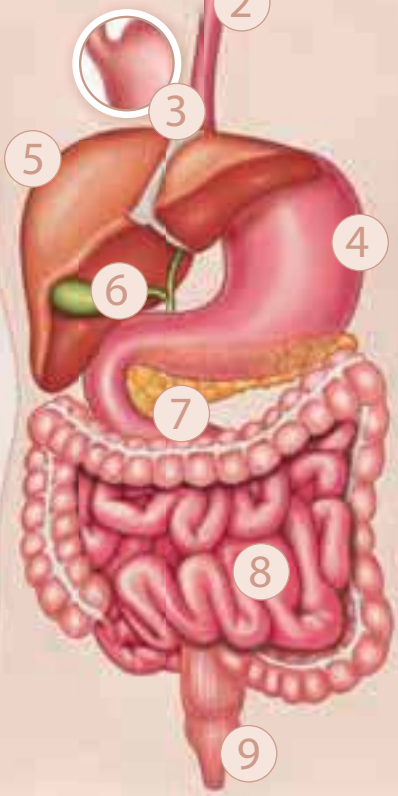
8 Small intestine:

Most of the nutrients form food are digested and absorbed in the small intestine.

Do you know? Small intestine is lined with mucosa, a layer of tissue that helps to absorb nutrients, produce digestive enzymes, and make mucus to protect the delicate intestinal wall.

9 Large intestine (Colon):

Most of the bacteria living in the digestive tract can be found in the large intestine. This is where the digestive process comes to an end.



1 Mouth:

Three pairs of salivary glands secrets saliva.
Enzymes in the saliva mix with food particles and start breaking them down while chewing.

3 Cardiac sphincter:

The Cardiac sphincter is where the oesophagus meets the stomach. This group of muscles acts like a gate to prevent stomach acid from going back up (refluxing) into the oesophagus.

4 Stomach:

Gastric juice contain HCl and gastric enzymes.

Hydrochloric acid (HCl) helps to digest proteins and other foods by pepsin enzymes while minimizing harmful bacteria.

7 Pancreas

The pancreas is connected to the duodenum where three important digestive enzmyes are made:

Protease	Lipase	Amylase
Helps digest protein	Helps digest fats	Helps digest carbohydrates

Fun fact:
There are two kinds of fibre, and both support a healthy colon.

Soluble fibre soaks up toxins and waste in the digestive system	Insolube fibre ("roughage") moves bulk through the intestine to help with regular bowel movements.

There are more then **100 trillion** bacterial cells in your body.

The digestive tract is home to a natural balance of good, bad, and neutral bacteria.

Do you know? Good bacteria, also called probiotics, support overall digestive and immune health.

Do you know? Up to 70% of our natural immune system support is in the digestive tract.

Here are 5 simple things you can do every day to maintain a healthy, balanced gut:

Eat a healthy diet | Drink plenty of water | Stay phyically active | Manage stress | Take a daily probiotic supplement

chylomicrons which are then transported into the lacteals within the intestinal villi and eventually empty into lymphatic duct. The lymphatic ducts ultimately release the absorbed substances into the blood stream. While the fatty acids are absorbed by the lymph duct, other materials are absorbed either actively or passively by the capillaries of the villi (Figure. 5.9). Water soluble vitamins are absorbed by simple diffusion or active transport. Transport of water depends upon the osmotic gradient.

Absorption of substances in the alimentary canal takes place in mouth, stomach, small intestine and large intestine. However maximum absorption takes place in the small intestine. Absorption of simple sugars, alcohol and medicines takes place in the stomach. Certain drugs are absorbed by blood capillaries in the lower side of the tongue and mucosa of mouth. Large intestine is also involved in absorption of more amounts of water, vitamins, some minerals and certain drugs.

1. What features of the small intestine enables it to absorb digested food efficiently?
2. What happens to the protein molecules in food, from the time it is swallowed, to the time its products are built up in the cytoplasm of a muscle cell.

Absorbed substances are transported through blood and lymph to the liver through the hepatic portal system. From the liver, nutrients are transported to all other regions of the body for utilization. All the body tissues utilize the absorbed substance for their activities and incorporate into their protoplasm, this process is called assimilation.

5.4 Egestion

The digestive waste and unabsorbed substances in the ileum enter into the large intestine and it mostly contains fibre called roughage. The roughage is utilized by symbiotic bacteria in the large intestine for the production of substances like vitamin K and other metabolites. All these substances are absorbed in the colon along with water. The waste is then solidified into faecal matter in the rectum. The faecal matter initiates a neural reflex causing an urge or desire for its removal. The egestion of faeces through the anal opening is called defaecation. It is a voluntary process and is carried out by a peristaltic movement.

5.5 Nutrients, Vitamins and Minerals

Food comprises of macronutrients and micronutrients. The nutrients required in larger quantities are called macronutrients, whereas those required in small quantities are called micronutrients. Essential nutrients cannot be synthesized by the body; they have to be included in the diet. Macronutrients are lipids, carbohydrates, proteins and the micronutrients are vitamins and minerals. Water plays an important role in the metabolic processes and prevents dehydration of the body.

Intake of too much of food or lesser amount of food than the basic requirement is called **malnutrition**. A diet which can provide all the metabolic requirements of the body in a right proportion is called **balanced diet**. That means it should

contain carbohydrates and fats for energy yielding, proteins for growth and replacement; and vitamins, minerals and water for physiological regulation.

Vitamins:

Vitamins are naturally occurring organic substances regularly needed in minute quantities for maintaining normal health as metabolic regulators. The identified vitamins are classified as fat soluble (A,D,E and K) and vitamin B and vitamin C are water soluble. Vitamin A, D, E and K, if consumed beyond required level may cause defects, commonly referred to as hypervitaminosis.

Minerals:

These are the inorganic chemical elements, i.e., Ca, Fe, I, K, Mg, Na, P, S, etc needed for regulation of various physiological functions. These can be classified into major minerals (Na, P, K, Ca, Mg, S, Cl) and others are trace minerals such as Fe, Cu, Zn, Co, Mn, I, and fluorine. Sodium ions are more abundant than any other cation in the body fluids.

N.I. Lunin discovered vitamins but the name vitamin was given by Dr. Funk (1912). The first vitamin isolated was B1 by Dr.Funk. The first vitamin produced by fermentation process using, *Acetobacter* bacteria is Vitamin C.

Table 1. Fat soluble vitamins

Vitamins	Functions	Symptoms of Deficiency
A (Retinol)/ Antixerophthalmic vitamin	Plays a vital role in visual perception. Maintenance and growth of epithelial tissue.	Night blindness **(Nyctalopia)**, Xerophthalmia (drying of eyeballs), **Bitot's spot** in the cornea, **Dermatosis** (dry and scaly skin) and **Keratomalacia** Atrophy of lacrymal glands and reduction in tear secretion
D (Calciferol)/ Antirachitic vitamin	Promotes intestinal absorption of calcium and phosphorus. Formation of teeth and bones.	**Rickets** in children (softness and deformities of bones and bow legs and pigeon chest) and **Osteomalacia** in adults (weak and fragile bones, bent, deformed pelvis).
E (Tocopherol) / Antisterility vitamin	Antioxidant It keeps the skin healthy by reduces the process of ageing.	**Sterility** in animals, Ruptured red blood cells
K Anti haemorrahagic vitamin.	1. Required for the synthesis of prothrombin in the liver.	Defect in blood clotting called Haemorrhagic manifestations.

Table 2. Water soluble vitamins		
Vitamins	**Functions**	**Symptoms of Deficiency**
B_1 (Thiamine)	Involved in carbohydrate metabolism. Act as a coenzyme	**Beriberi:** affects muscular, nervous and cardiovascular system
B_2 (Riboflavin)	Acts as coenzyme in oxidation and reduction reactions	Inflammation, soreness and fissures in the corners of the mouth, lips and tongue. Loss of appetite. Skin and eye disorder.
B_3 (Pantothenic acid)	Acts as coenzyme A and is essential for the metabolism of fats and carbohydrates	Gastrointestinal disorders, anaemia, Burning feet syndrome, etc.
B_4 (choline)	Precursor for acetylcholine	Fatty liver.
B_5 (Niacin / Nicotinic acid)	Derivatives of coenzymes	**Pellagra** (4D Syndrome) characterised by dermatitis, diarrhoea and dementia (mental deterioration) and death.
B_6 (Pyridoxine)	Haemoglobin formation, brain, heart and liver activities	**Dermatitis,** convulsions, muscular twitching and **anaemia**
B_7 (Biotin) / Vit.H	Acts as a coenzyme in synthesis of fat, glycogen and amino acids	**Dermatitis**
B_9 (Folic acid)	It acts as a co-enzyme for synthesis of nucleic acid and essential for growth and formation of RBC	**Megaloblastic anaemia** (large, immature, nucleated RBC in blood)
B_{12} (Cobalamine)	Promotes DNA synthesis. Necessary for maturation of RBC and formation of myelin sheath.	**Pernicious anaemia** (immature nucleated RBC without haemoglobin). Causes nervous disorder.
C (Ascorbic acid)	Acts as an antioxidant. Strengthens the immune system. Necessary for healthy gums and teeth.	**Scurvy** (Sailor's disease) characterized by spongy and bleeding gums, falling of teeth, fragile bones, delayed wound healing etc. - Infantile scurvy)

Food adulterants cause harmful effects in the form of headaches, palpitations, allergies, cancers and in addition reduces the quality of food. Common adulterants are addition of citric acid to lemon juice, papaya seeds to pepper, melamine to milk, vanillin for natural vanillin, red dyes to chillis, lead chromate and lead tetraoxide to turmeric powder, etc.,

5.6. Caloric value of carbohydrates, proteins and fats

We obtain 50% energy from carbohydrates 35% from fats and 15% from proteins. We require about 400 to 500 gm of carbohydrates, 60 to 70 gm of fats and 65 to 75 gm of proteins per day. Balanced diet of each individual will vary according to their age, gender, level of physical activity and others conditions such as pregnancy and lactation.

Carbohydrates are sugar and starch. These are the major source of cellular fuel which provides energy. The caloric value of carbohydrate is 4.1 calories per gram and its physiological fuel value is 4 Kcal per gram.

Lipids are fats and derivatives of fats, are also the best reserved food stored in our body which is used for production of energy. Fat has a caloric value of 9.45 Kcal and a physiological fuel value of 9 Kcal per gram.

Many research findings have proven that usage of chemical preservatives and artificial enhancers lead to highly harmful effects. It includes heart ailments, hypertension, infertility, gastrointestinal disorders, early puberty in girls, weakening of bones, damage in organs like kidney and liver, chronic obstructive pulmonary diseases, headache, allergies, asthma, skin rashes and even cancer. Remember that nothing will beat and overtake the taste and safety of homemade foods. "East or west home preparation is the best."

Proteins are source of amino acids required for growth and repair of body cells. They are stored in the body only to a certain extent; large quantities are excreted as nitrogenous waste. The caloric value and physiological fuel value of one gram of protein are 5.65 Kcal and 4 Kcal respectively. According to ICMR (Indian Council of Medical Research and WHO (World Health Organization), the daily requirement of protein for an average Indian is 1gm per 1 kg body weight.

5.7. Nutritional and digestive disorders

Intestinal tract is more prone to bacterial, viral and parasitic worm infections. This infection may cause inflammation of the inner lining of colon called colitis. The most common symptoms of colitis are rectal bleeding, abdominal cramps, and diarrhoea.

Protein energy malnutrition: (PEM)

Growing children require more amount of protein for their growth and development. Protein deficient diet during early stage of children may lead to protein energy malnutrition such as **Marasmus and Kwashiorkor**. Symptoms are dry skin, pot-belly, oedema in the legs and face, stunted growth, changes in hair colour, weakness and irritability. Marasmus is an acute form of protein malnutrition. This condition is due to a diet with inadequate carbohydrate and protein. Such children are suffer from diarrhoea, body becomes lean and weak (emaciated) with reduced fat and muscle tissue with thin and folded skin.

Indigestion: It is a digestive disorder in which the food is not properly digested leading to a feeling of fullness of stomach. It may be due to inadequate enzyme secretion, anxiety, food poisoning, over eating, and spicy food.

Constipation: In this condition, the faeces are retained within the rectum because of irregular bowel movement due to poor intake of fibre in the diet and lack of physical activities.

Vomiting: It is reverse peristalsis. Harmful substances and contaminated food from stomach are ejected through the mouth. This action is controlled by the vomit centre located in the medulla oblongata. A feeling of nausea precedes vomiting.

Jaundice: It is the condition in which liver is affected and the defective liver fails to break down haemoglobin and to remove bile pigments from the blood. Deposition of these pigments changes the colour of eye and skin yellow. Sometimes, jaundice is caused due to hepatitis viral infections.

Liver cirrhosis: Chronic disease of liver results in degeneration and destruction of liver cells resulting in abnormal blood vessel and bile duct leading to the formation of fibrosis. It is also called deserted liver or scarred liver. It is caused due to infection, consumption of poison, malnutrition and alcoholism.

Gall Stones: Any alteration in the composition of the bile can cause the formation of stones in the gall bladder. The stones are mostly formed of crystallized cholesterol in the bile. The gall stone causes obstruction in the cystic duct, hepatic duct and also hepato-pancreatic duct causing pain, jaundice and pancreatitis.

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Appendicitis: It is the inflammation of the vermiform appendix, leading to severe abdominal pain. The treatment involves the removal of appendix by surgery. If treatment is delayed the appendix may rupture and results in infection of the abdomen, called peritonitis.

Hiatus hernia (Diaphragmatic hernia): It is a structural abnormality in which superior part of the stomach protrudes slightly above the diaphragm. The exact cause of hiatus hernias is not known. In some people, injury or other damage may weaken muscle tissue, by applying too much pressure (repeatedly) on the muscles around the stomach while coughing, vomiting, and straining during bowel movement and lifting heavy object. Heart burn is also common in those with a hiatus hernia. In this condition, stomach contents travel back into the oesophagus or even into oral cavity and causes pain in the centre of the chest due to the eroding nature of acidity (Figure.5.10).

Diarrhoea: It is the most common gastrointestinal disorder worldwide. It is sometimes caused by bacteria or viral infections through food or water. When the colon is infected, the lining of the intestine is damaged by the pathogens, thereby the colon is unable to absorb fluid. The abnormal frequency of bowel movement and increased liquidity of the faecal discharge is known as diarrhoea. Unless the condition is treated, dehydration can occur. Treatment is known as **oral hydration therapy**. This involves drinking plenty of fluids – sipping small amounts of water at a time to rehydrate the body.

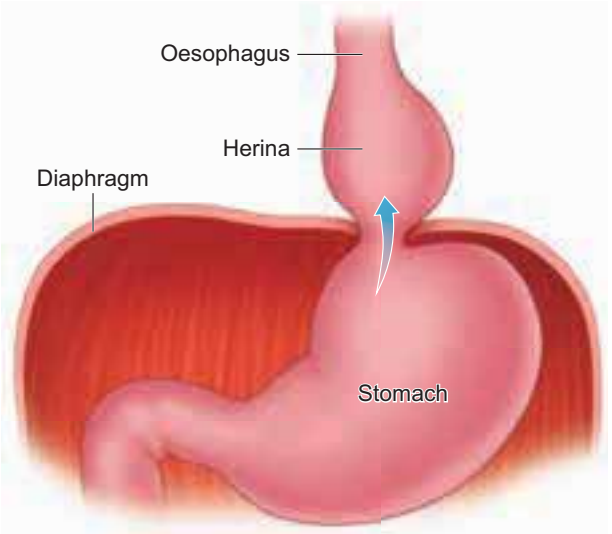


Figure 5.10 Hiatus hernia

Peptic ulcer: It refers to an eroded area of the tissue lining (mucosa) in the stomach or duodenum. Duodenal ulcer occurs in people in the age group of 25 - 45 years. Gastric ulcer is more common in persons above the age of 50 years. Ulcer is mostly due to infections caused by the bacterium ***Helicobacter pylori.*** It may also be caused due to uncontrolled usage of aspirin or certain antiinflammatory drugs. Ulcer may also be caused due to smoking, alcohol, caffeine and psychological stress.

Obesity: It is caused due to the storage of excess of body fat in adipose tissue. It may induce hypertension, atherosclerotic heart disease and diabetes. Obesity may be genetic or due to excess intake of food, endocrine and metabolic disorders. Degree of obesity is assessed by body mass index (**BMI**). A normal BMI range for adult is 19-25; above 25 is considered as obese. BMI is calculated as body weight in Kg, divided by the square of body height in meters. For example, a 50 Kg person with a height of 160 cms would have a BMI of 19.5.

That is BMI = $50/1.6^2 = 19.5$

DO YOU KNOW?

Nobel Prize for the year 2005 was awarded to Robin Warren and Barry Marshall for the discovery of *Helicobacter pylori* which causes peptic ulcer.

Activity

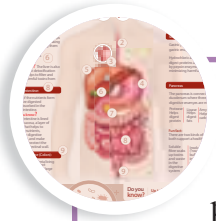
Test for Starch: Add a few drops of iodine to the given warm food sample. If any starch is present in the given food sample it will change the colour of the iodine from brown to blue-black.

Test for protein: Mix the given food sample with 3mL of water in a test tube. Shake the mixture, and then add a few drops of Biuret solution. If protein is present, the colour of the solution will change to purple.

Test for glucose: Mix the given food sample with 3mL of water in a test tubes. Shake the mixture, and then add a few drops of Benedict's solution. Keep the test tube in a water bath and heat carefully. If glucose is present, the colour of the solution will change from blue to green to brick red depending upon the amount of glucose.

ICT Corner

Let's Digest



Let's explore the activity to know process of **digestion**.

Step – 1

Use the URL to open the 'Interactive Digestive System' page. Click the 'View Digestive System'.

Step – 2

Roll the mouse over the interactive diagram and place the cursor on any of the parts to learn about the parts.

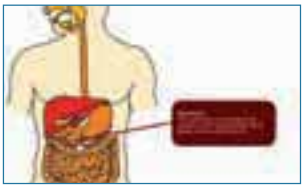
Step – 3

Click the 'Explore the digestive system' to observe the process of digestion right from the mouth to the anus.

Step – 4

During the exploration, questions will be asked and only correct answers will lead you to proceed. Answer all the questions and finish the process of digestion.

Step 1



Step 2

Step 3

Step 4

Explore your digestive system'sURL:

http://www.open.edu/openlearn/nature-environment/natural-history/explore-your-digestive-system

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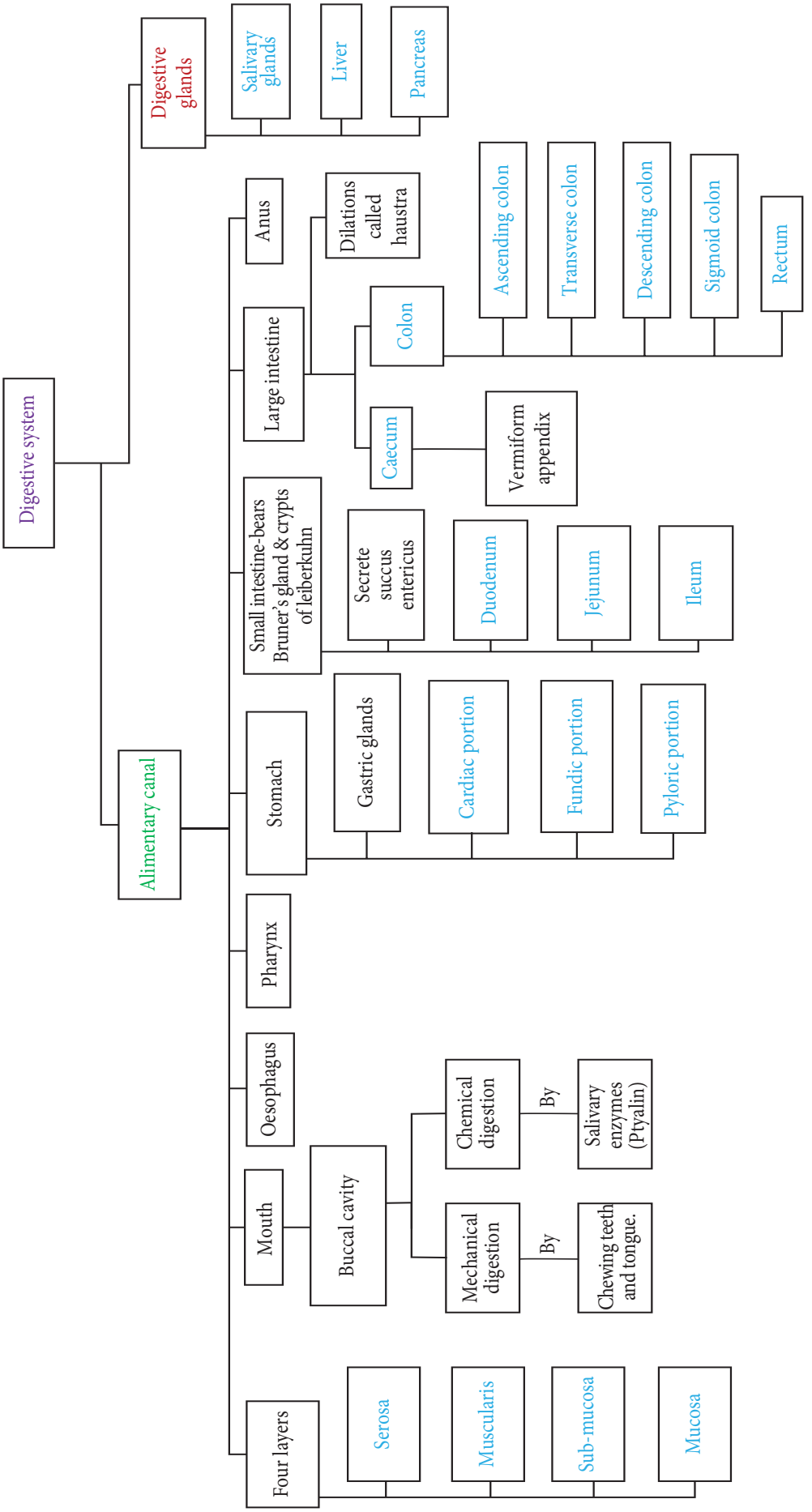
* Pictures are indicative only

Summary

Alimentary canal		
Organs	**Functions**	**Secretions**
Mouth	Receive food, starts mechanical digestion by chewing with the help of teeth and tongue.	—
Pharynx	Swallowing	—
Esophagus	conduction of the food to stomach	—
Stomach	Stores and churns food. Initiates protein digestion. Limited absorption.	Mucus protects stomach. HCL activates enzymes and kills germs. Pepsin digests protein. Gastrin hormone stimulates HCl and pepsinogen secretion.
Small Intestine	Completes digestion and absorbs nutrients	Mucus protects gut wall. Peptidases digest proteins. Maltase, lactase and sucrase digest sugars. Lipase digests lipids. Nuclease digests nucleic acids. Cholecystokinin triggers the release of pancreatic juices and bile from the gallbladder.
Large Intestine	Reabsorbs water, ions, vitamins. Stores wastes.	—
Rectum	Expels wastes	—
Anus	Opening for waste elimination	—

Accessory digestive glands		
Glands	**Functions**	**Secretions**
Salivary Glands	Moistens food	Salivary mucus lubricates food. Salivary amylase (Ptyalin) digests starch.
Liver	Produces Bile, synthesises cholesterol and steroids. Destroys old blood cells. Detoxifies poisons produced by bacteria and others in food. Breaks heamoglobin of dead and damaged RBC and convert into bile pigments.	Bile emulsifies fat
Gall Bladder	Stores bile	
Pancreas	Exocrine part secretes digestive enzymes. Endocrine part secretes hormones such as insulin by beta cells, glucagon by alpha cells which regulates blood glucose levels.	Bicarbonate neutralizes stomach acid. Trypsin and chymotrypsin digest proteins. Carboxypeptidase digests peptides. Amylase digests starch and glycogen. Lipase digests lipids. Nuclease digests nucleic acids.

Concept Map



Glossary

Ampulla of vater – Common duct called hepato-pancreatic duct

Bartholin's duct or duct of rivinis – Duct of sublingual gland

Crypts of leiberkuhn – crypts between the base of villi in the wall of the small intestine

Falciform ligament – It seperate lobes of liver connect the liver with diaphragm

Gastric rugae – Folds in wall of stomach

Glisson's capsule – Thin connective tissue sheath which covers the hepatic lobules

Goblet cells – Mucus secreting glands

Haustra – Pouch like dilation in the colon

Sphincter of boydon – Sphincter which guard opening of the bile duct before it joins with the pancreatic duct

Sphincter of oddi – Sphincter which guard the opening of the ampulla of vater into the duodenum

Stenson's duct – Duct of parotids gland

Succus entericus – Intestinal juice

Taeniae coli – Longitudinal muscular chords in the colon

Valves of kerkring or plicae circulares – **Circular fo**lds in the lumen of ileum

Wharton's duct – Duct of sub-maxillary/ sub-mandibular gland

Evaluation

1. Choose the incorrect sentence from the following:
   a. Bile juice emulsifies the fat.
   b. Chyme is a digestive acidic food in stomach.
   c. Pancreatic juice converts lipid into fatty acid and glycerol.
   d. Enterokinase stimulates the secretion of pancreatic juice.
2. What is chyme….?
   a. The process of conversion of fat into small droplets.
   b. The process of conversion of micelles substances of glycerol into fatty droplet.
   c. The process of preparation of incompletely digested acidic food through gastric juice.
   d. The process of preparation of completely digested liquid food in midgut.
3. Which of the following hormones stimulate the production of pancreatic juice and bicarbonate?
   a. Angiotensin and epinephrine
   b. Gastrin and insulin
   c. Cholecysokinin and secretin
   d. Insulin and glucagon
4. The sphincter of Oddi guards
   a. Hepatopancreatic duct
   b. Common bile duct
   c. Pancreatic duct
   d. Cystic duct
5. In small intestine, active absorption occurs in case of
   a. Glucose b. Amino acids
   c. Na+ d. All the above

6. Which one is incorrectly matched?
   a. Pepsin – stomach
   b. Renin – liver
   c. Trypsin – intestine
   d. Ptyalin – mouth
7. Absorption of glycerol, fatty acids and monoglycerides takes place by
   a. Lymph vessels within villi
   b. Walls of stomach
   c. Colon
   d. Capillaries within villi
8. First step in digestion of fat is
   a. Emulsification
   b. Enzyme action
   c. Absorption by lacteals
   d. Storage in adipose tissue
9. Enterokinase takes part in the conversion of
   a. Pepsinogen into pepsin
   b. Trypsinogen into trypsin
   c. Protein into polypetide
   d. Caseinogen into casein
10. Which of the following combinations are not matched?
    a. Vitamin D - Rickets
    b. Thiamine - Beriberi
    c. Vitamin K - Sterility
    d. Niacin - Pellagra
11. Which of the following combinations are not matched?

	Column I	Column II
a.	Bilirubin and biliverdin	(i) intestinal juice
b.	Hydrolysis of starch	(ii) Amylases
c.	Digestion of fat	(iii) Lipases
d.	Salivary gland	(iv) Parotid

12. Match column I with column II and choose the correct option

Column – I	Column – II
(P) Small intestine	(i) Largest factory
(Q) Pancreas	(ii) Absorpstion of glucose
(R) Liver	(iii) Carrying electrolytic solution
(S) Colon	(iv) Digestion and absorption

    a. (P-iv) (Q -iii) (R- i) (S – ii)
    b. (P-iii) (Q -ii) (R- i) (S – iv)
    c. (P-iv) (Q -iii) (R- i) (S – ii)
    d. (P-ii) (Q -iv) (R- iii) (S – i)
13. Match column I with column II and choose the correct option

Column – I	Column – II
(P) Small intestine	(i) 23 cm
(Q) Large intestine	(ii) 4 meter
(R) Oesophagus	(iii) 12.5 cm
(S) Pharynx	(iv) 1.5 meter

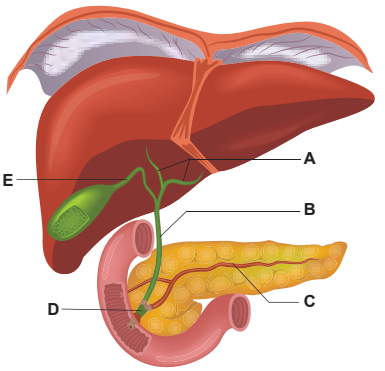
    a. (P-iv) (Q -ii) (R- i) (S – iii)
    b. (P-ii) (Q -iv) (R- i) (S – iii)
    c. (P-i) (Q -iii) (R- ii) (S – iv)
    d. (P-iii) (Q -i) (R- ii) (S – iv)
14. Match column I with column II and choose the correct option

Column – I	Column – II
(P) Lipase	(i) Starch
(Q) Pepsin	(ii) Cassein
(R) Renin	(iii) Protein
(S) Ptyalin	(iv) Lipid

    a. (P-iv) (Q -ii) (R- i) (S – iii)
    b. (P-iii) (Q -iv) (R- ii) (S – i)
    c. (P-iv) (Q -iii) (R- ii) (S – i)
    d. (P-iii) (Q -ii) (R- iv) (S – i)

15. Which of the following is not the function of liver?
    a. Production of insulin
    b. Detoxification
    c. Storage of glycogen
    d. Production of bile
16. Assertion : (A) Large intestine also shows the presence of villi like small intestine.

    Reason: (B) Absorption of water takes place in large intestine.
    a. Both A and B are true and B is the correct explanation of A
    b. Both A and B are true but B is not the correct explanation of A
    c. A is true but B is false
    d. A is false but B is true
17. Which of the following is not true regarding intestinal villi?
    a. They possess microvilli.
    b. They increase the surface area.
    c. They are supplied with capillaries and the lacteal vessels.
    d. They only participate in digestion of fats.
18. Why are villi present in the intestine and not in the stomach?
19. Bile juice contains no digestive enzymes, yet it is important for digestion. Why?
20. List the chemical changes that starch molecule undergoes from the time it reaches the small intestine.
21. How do proteins differ from fats in their energy value and their role in the body?
22. Digestive secretions are secreted only when needed. Discuss.
23. Label the given diagram.



References

1. Guyton and Hall. J. E, (2006) Textbook of Medical Physiology- Eleventh Edition Elsevier saunders. International Edition.
2. Brooker et.al. (2008), Biology Volume two Plants and Animals, The MacGraw Hill companies,inc.
3. Elaine N. and Katja (2010). Human Anatomy and Physiology Eighth Edition, Benjamin Cummings, Pearson. New York.

Web links

Multiple interactive informational activities and resources	http://www.bbc.co.uk/science/humanbody/
Interactive tour of the digestive tract	http://www.medtropolis.com/VBody.asp
United States Department of Agriculture web site on nutrition; resources on dietary guidelines; food pyramids; recipes for healthy eating	http://www.usda.gov/cnpp/

UNIT III Chapter 6

Respiration

Chapter Outline

Exercise increases the rate and depth of breathing and supplies extra oxygen to the muscles and removes more CO_2 from the tissues.

Learning Objectives:

- *Learns to describe the gross structure of the human gaseous exchange system*
- *Observes and draws the tissues and organs associated with the respiratory system*
- *Understands the process of gaseous exchange and transport of respiratory gases*
- *Knows the problems associated with oxygen transport*
- *Gains knowledge on the ill–effects of smoking.*

6CKTEG

We inhale and exhale air. Why is breathing so important for life? What happens when we breathe? Why energy is required for the body to perform various life processes? Where does the energy come from? We eat food for energy. Though the above raised questions look disconnected, we should know that the process of breathing is connected to the process of release of energy from food. Oxygen is utilized by the organisms to breakdown the biomolecules like glucose and to derive energy. During this breakdown carbondioxide, which is a harmful gas is also released. It is very obvious that oxygen has to be provided to cells continuously and the CO_2 to be released immediately by the cells. So the need of a respiratory system is essential for life.

We have discussed in the previous chapter how food provides energy for growth and repair of tissues. As mentioned earlier along with food, oxygen is necessary for breakdown of glucose to energy. In this chapter we shall discuss the respiratory organs of human, the mechanism of breathing, exchange and transport of gases and a few respiratory disorders.

The term respiration refers to the exchange of oxygen and carbondioxide between environment and cells of our body where organic nutrients are broken down enzymatically to release energy.

6.1 Respiratory functions

The five primary functions of the respiratory system are –

i. To exchange O_2 and CO_2 between the atmosphere and the blood.
ii. To maintain homeostatic regulation of body pH.
iii. To protect us from inhaled pathogens and pollutants.
iv. To maintain the vocal cords for normal communication (vocalization).
v. To remove the heat produced during cellular respiration through breathing.

6.2 Respiratory organs in various organisms.

Different animals have different organs for exchange of gases, depending upon their habitats and levels of organization. The amount of dissolved oxygen is very low in water compared to the amount of oxygen in the air. So the rate of breathing in aquatic organisms is much faster than land animals.

In animals like sponges, coelenterates and flatworms exchange of gases takes place through the body surface by simple diffusion. Earthworms use their moist skin, whereas insects have tracheal tubes. Gills are used as respiratory organs in most of the aquatic Arthropods and Molluscs. Among verterbrates, fishes use gills whereas amphibians, reptiles, birds and mammals have well vascularised lungs. Frogs spend most of their time in water and also use their moist skin for respiration along with lungs.

6.2.1 Human Respiratory System

The respiratory system includes the external nostrils, nasal cavity, the pharynx, the larynx, the trachea, the bronchi and bronchioles and the lungs which contain the alveoli (Figure 6.1). The parts starting from the external nostrils up to the terminal bronchioles constitute the conducting zone, whereas the alveoli and the ducts are called the respiratory zone. The parts of the conducting zone, humidifies and warms the incoming air.

In human beings, air enters the upper respiratory tract through the external nostrils. The air passing through the nostrils is filtered by fine hairs and mucus lining the passage. The external nostrils lead to the nasal chamber which opens into the nasopharynx which opens through the glottis of the larynx region into the trachea. The ciliated epithelial cells lining the trachea, bronchi and bronchioles secrete mucus. Mucus membrane lining the airway contains goblet cells which secrete mucus, a slimy material rich in glycoprotein. Microorganisms and dust particles attach in the mucus films and

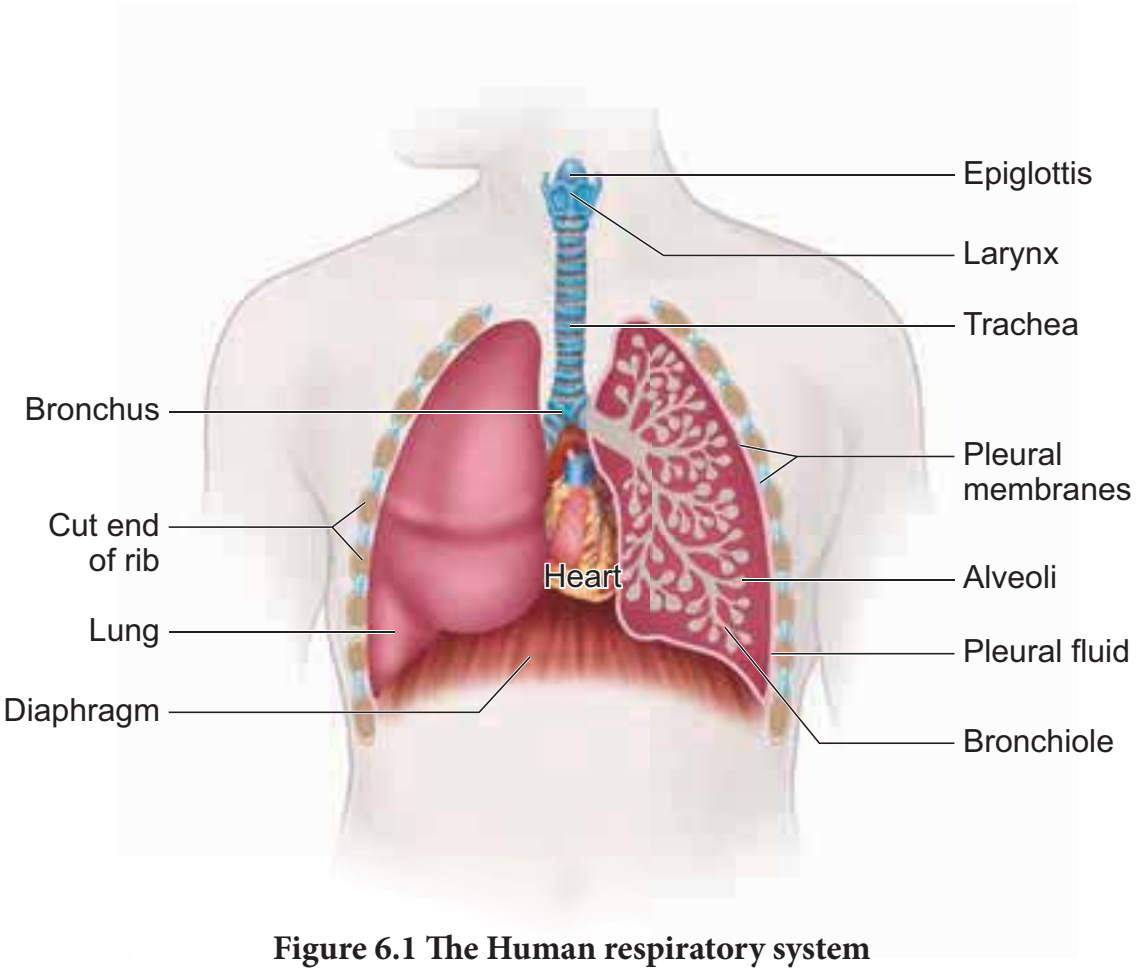


Figure 6.1 The Human respiratory system

are carried upwards to pass down the gullet during normal swallowing. During swallowing a thin elastic flap called epiglottis prevents the food from entering into the larynx and avoids choking of food.

The trachea is semiflexible tube supported by multiple cartilaginous rings which extends up to the midthoracic cavity and at the level of the 5th thoracic vertebra where it divides into right and left primary bronchi, one bronchus to each lung. Within the lungs the bronchi divides repeatedly into secondary and tertiary bronchi and further divides into terminal bronchioles and respiratory bronchioles.

It is advised not to talk or laugh louder while eating. Can you give the reason?

Bronchi have 'C' shaped curved cartilage plates to ensure that the air passage does not collapse or burst as the air pressure changes during breathing. The bronchioles are without cartilaginous rings and have rigidity that prevent them from collapsing but are surrounded by smooth muscle which contracts or relaxes to adjust the diameter of these airways.

The fine respiratory bronchioles terminate into highly vascularised thin walled pouch like air sacs called alveoli meant for gaseous exchange (Figure 6.2, 6.3). The diffusion membrane of alveolus is made up of three layers – the thin squamous epithelial cells of the alveoli, the endothelium of the alveolar capillaries and the basement substance found in between them. The thin squamous epithelial cells of the alveoli are composed of Type I and

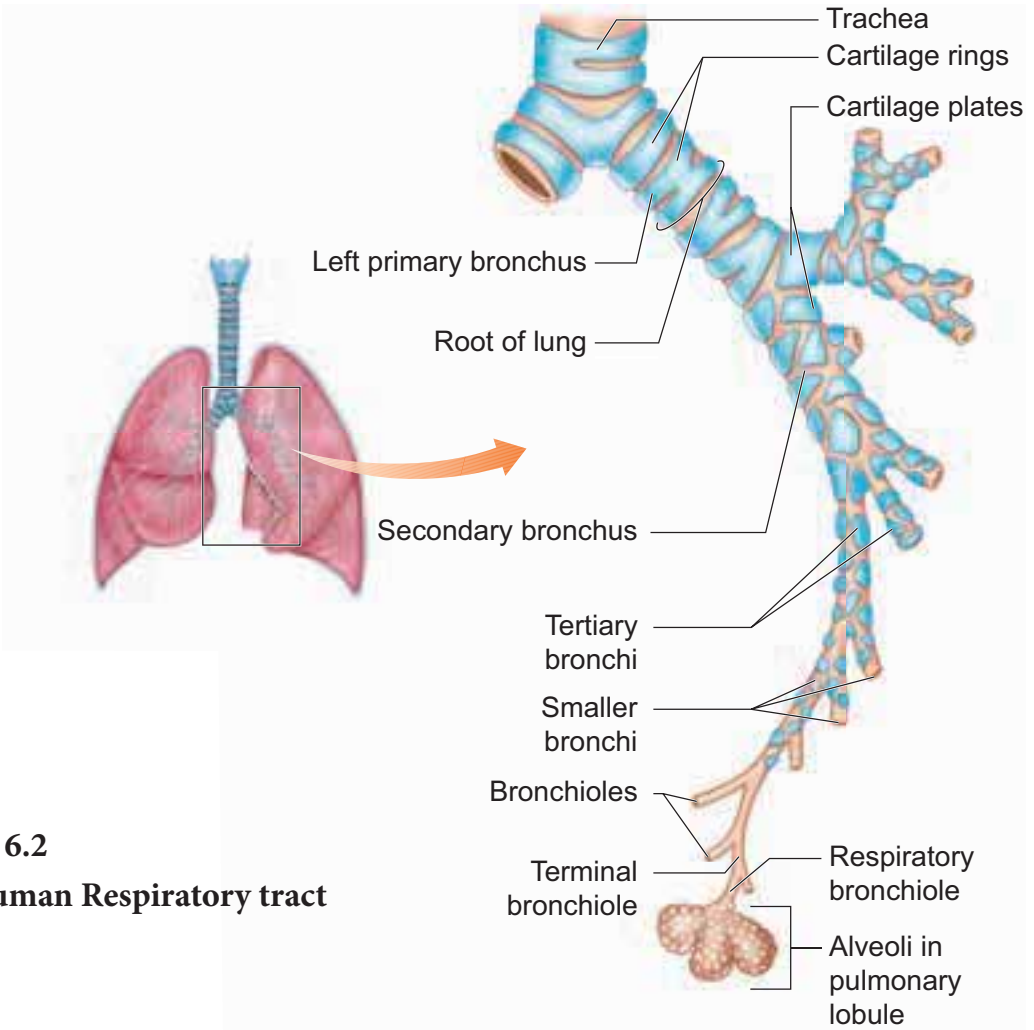


Figure 6.2
The Human Respiratory tract

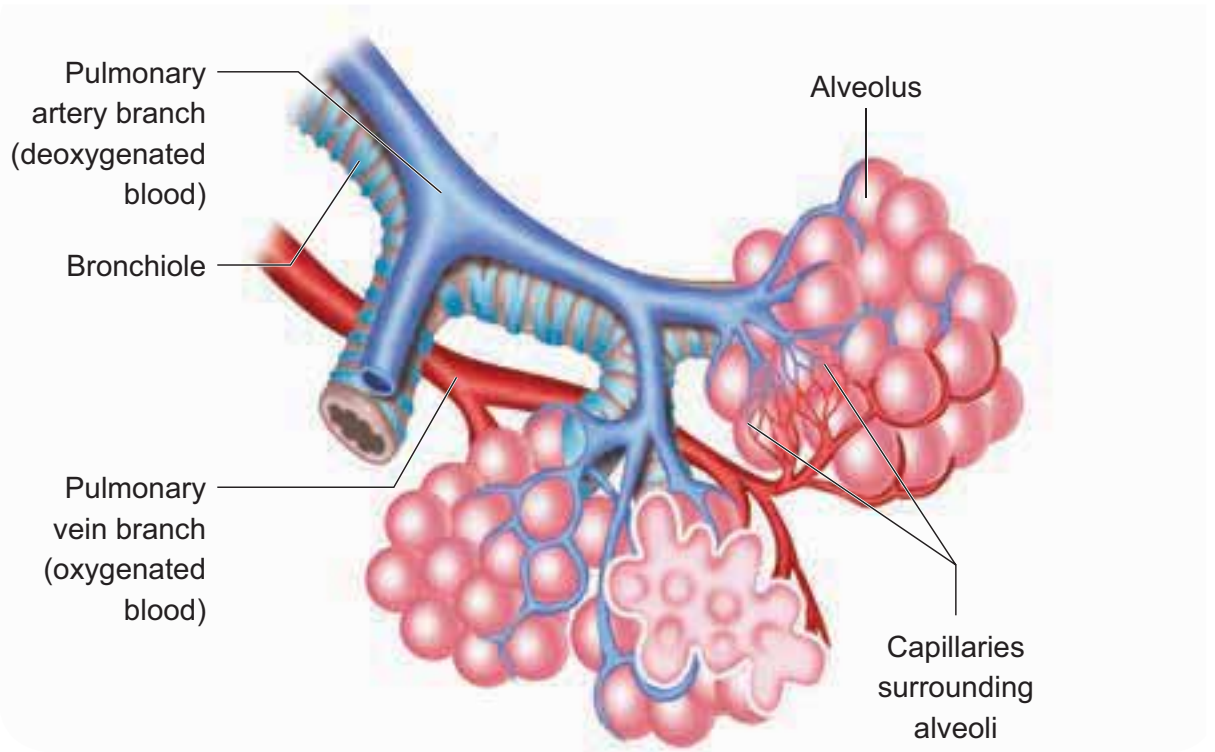


Figure 6.3 Structure of alveoli

Type II cells. Type I cells are very thin so that gases can diffuse rapidly through them. Type II cells are thicker, synthesize and secrete a substance called **Surfactant**.

The lungs are light spongy tissues enclosed in the thoracic cavity surrounded by an airtight space. The thoracic cavity is bound dorsally by the vertebral column and ventrally by the sternum, laterally by the ribs and on the lower side by the dome shaped diaphragm.

The lungs are covered by double walled pleural membrane containing a several layers of elastic connective tissues and capillaries, which encloses the pleural fluid. Pleural fluid reduces friction when the lungs expand and contract.

Characteristic features of respiratory surface:

- surface area must be very large and richly supplied with blood vessels
- should be extremely thin and kept moist
- should be in direct contact with the environment
- should be permeable to respiratory gases

The steps involved in respiration are

i. The exchange of air between the atmosphere and the lungs.

ii. The exchange of O_2 and CO_2 between the lungs and the blood.

iii. Transport of O_2 and CO_2 by the blood.

iv. Exchange of gases between the blood and the cells.

v. Uptake of O_2 by the cells for various activities and the release of CO_2.

DO YOU KNOW?

SURFACTANTS are the thin non–cellular films made of protein and phospholipids covering the alveolar membrane. The surfactant lowers the surface tension in the alveoli and prevents the lungs from collapsing. It also prevents pulmonary oedema. Premature Babies have low levels of surfactant in the alveoli may develop the new born respiratory distress syndrome (NRDS) because the synthesis of surfactants begins only after the 25th week of gestation.

6.3. Mechanism of breathing

The movement of air between the atmosphere and the lungs is known as ventilation or breathing. Inspiration and expiration are the two phases of breathing. Inspiration is the movement of atmospheric air into the lungs and expiration is the movement of alveolar air that diffuse out of the lungs. (Figure 6.4)

Lungs do not contain muscle fibres but expands and contracts by the movement of the ribs and diaphragm. The diaphragm is a sheet of tissue which separates the thorax from the abdomen. In a relaxed state, the diaphragm is domed shaped.

Observe a live fish and find out how many times it beats the operculum per minute. Now check your rate of breathing for a minute. The rate of breathing will be more in fish than you – Give reasons.

Ribs are moved by the intercostal muscles. External and internal intercostal muscles found between the ribs and the diaphragm helps in creating pressure gradients. Inspiration occurs if the pressure inside the lungs (intrapulmonary pressure) is less than the atmospheric pressure likewise expiration takes place when the pressure within the lungs is higher than the atmospheric pressure.

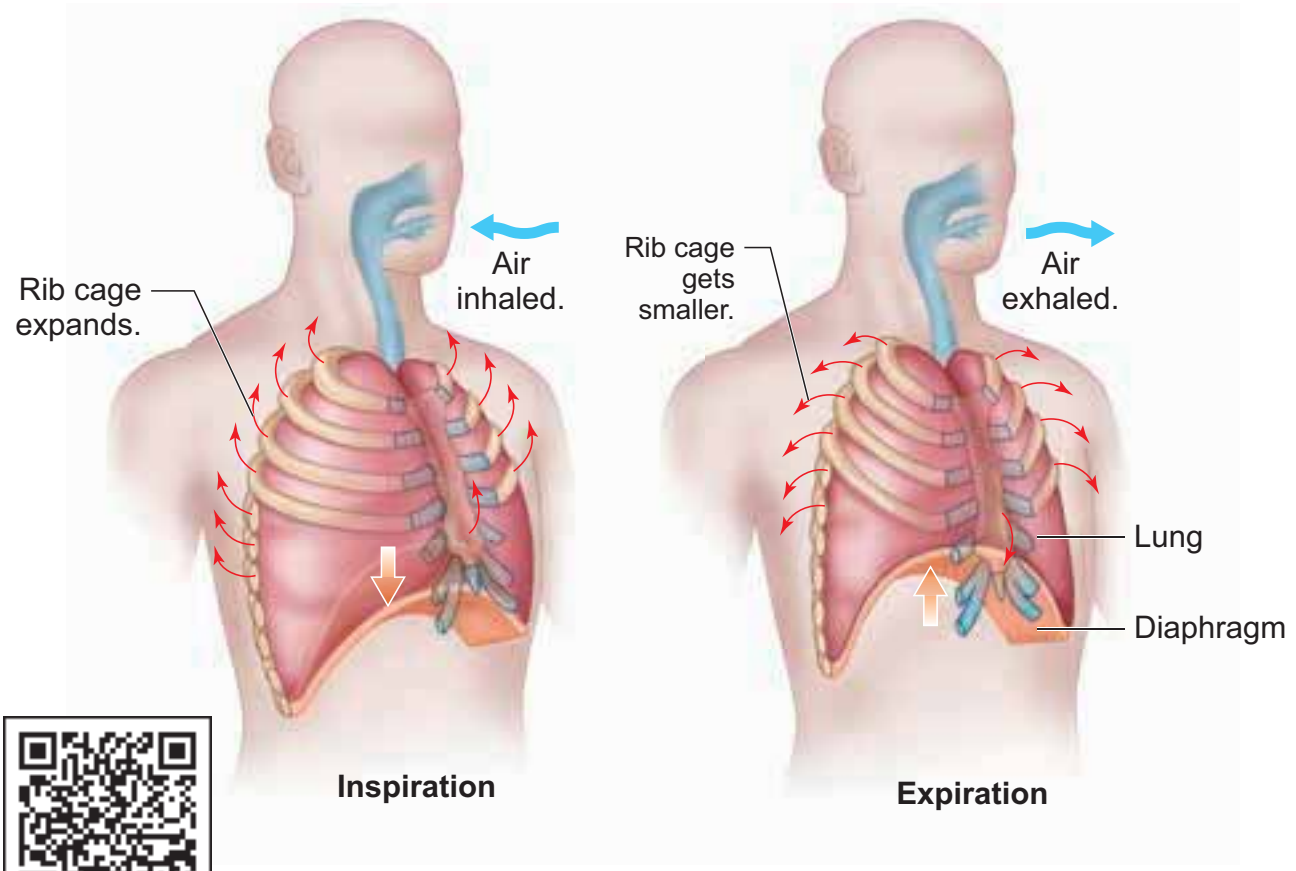


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Figure 6.4 Mechanism of breathing

Why do some people snore? – Breathing with a hoarse sound during sleep is caused by the vibration of the soft palate. Snoring is caused by a partially closed upper air way (nose and throat) which becomes too narrow for enough air to travel through the lungs. This makes the surrounding tissues to vibrate and produces the snoring sound.

Inspiraton is initiated by the contraction of the diaphragm muscles and external intercostal muscles, which pulls the ribs and sternum upwards and outwards and increases the volume of the thoracic chamber in the dorso–ventral axis, forcing the lungs to expand the pulmonary volume. The increase in pulmonary volume and

You are at high level in a mountain above the sea level. Suddenly you get palpitation and nausea. What condition are you suffering from? What are the other symptoms for this disease and how can it be reduced?

decrease in the intrapulmonary pressure forces the fresh air from outside to enter the air passages into the lungs to equalize the pressure. This process is called **inspiration.**

Relaxation of the diaphragm allows the diaphragm and sternum to return to its dome shape and the internal intercostal muscles contract, pulling the ribs downward reducing the thoracic volume and pulmonary volume. This results in an increase in the intrapulmonary pressure slightly above the atmospheric pressure causing the expulsion of air from the lungs. This process is called **expiration.**

On an average, a healthy human breathes 12–16 times/minute. An instrument called Spirometer is used to measure the volume of air involved in breathing movements for clinical assessment of a person's pulmonary function.

6.3.1 Respiratory volumes and capacities

The volume of air present in various phases of respiration is denoted as

Respiratory volumes: (Figure 6.5)

- **Tidal Volume (TV)** Tidal volume is the amount of air inspired or expired with each normal breath. It is approximately 500 mL., i.e. a normal human adult can inspire or expire approximately 6000 to 8000mL of air per minute. During vigorous exercise, the tidal volume is about 4–10 times higher.

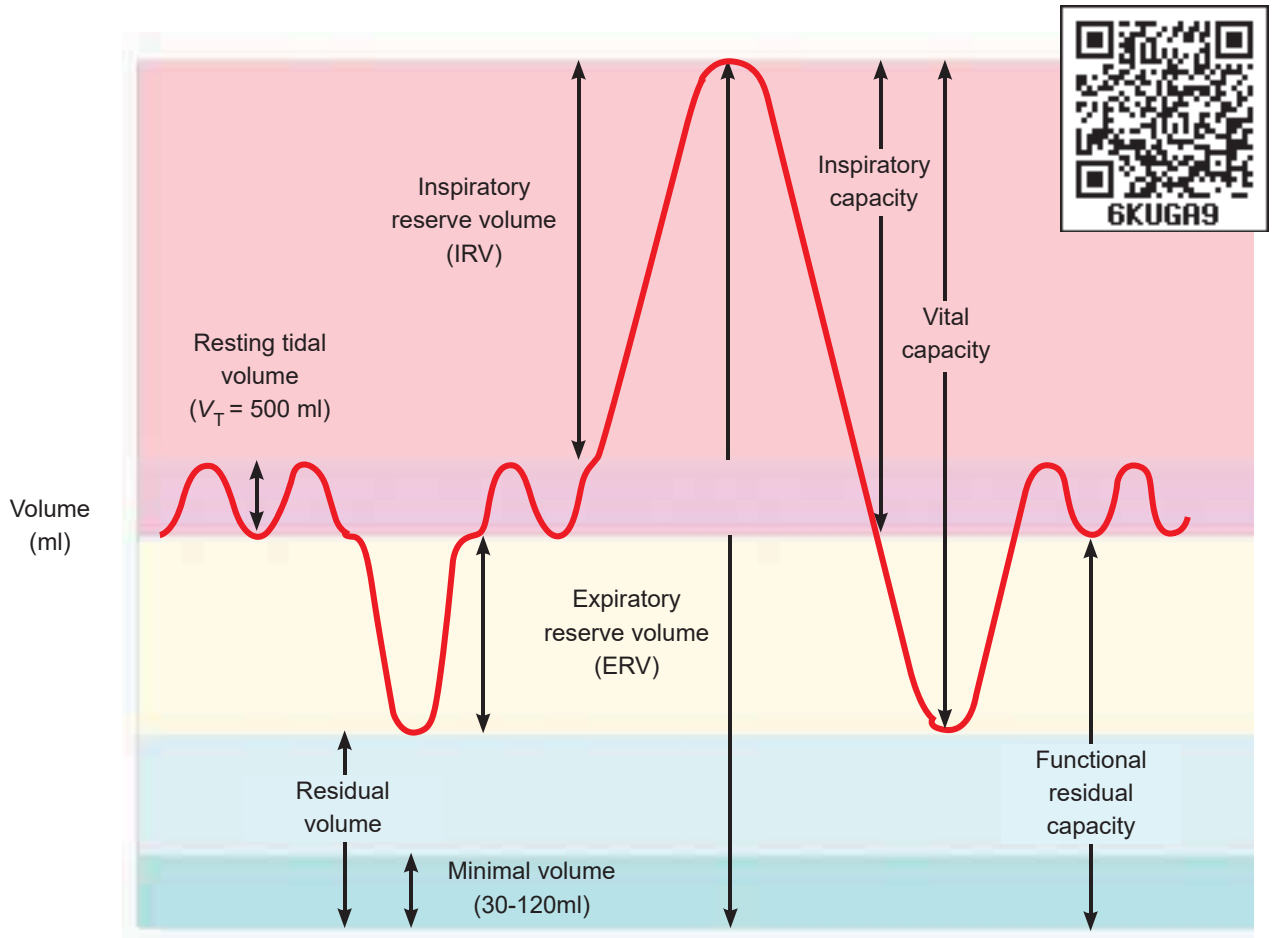


Figure 6.5 Lung volumes and capacity

Healthy lungs contain large amounts of elastic connective tissue around the alveoli, containing elastin, which makes the lung tissue elastic. People with emphysema and bronchitis have difficulty in exhaling because the enzyme elastase destroys the elastin around the alveoli and reduces the elasticity of the lungs.

- **Inspiratory Reserve volume (IRV)** Additional volume of air a person can inspire by forceful inspiration is called Inspiratory Reserve Volume. The normal value is 2500–3000 mL.
- **Expiratory Reserve volume (ERV)** Additional volume of air a person can forcefully exhale by forceful expiration is called Expiratory Reserve Volume. The normal value is 1000–1100 mL.
- **Residual Volume (RV)** The volume of air remaining in the lungs after a forceful expiration. It is approximately 1100–1200 mL.

Respiratory capacities:

- **Vital capacity (VC)** the maximum volume of air that can be moved out during a single breath following a maximal inspiration. A person first inspires maximally then expires maximally. VC=ERV+TV+IRV
- **Inspiratory capacity (IC)** The total volume of air a person can inhale after normal expiration. It includes tidal volume and inspiratory reserve volume. IC=TV+IRV
- **Expiratory capacity (EC)** The total volume of air a person can exhale after normal inspiration. It includes tidal volume and expiratory reserve volume. EC=TV+ERV
- **Total Lung Capacity (TLC)** The total volume of air which the lungs can accommodate after forced inspiration is called Total Lung Capacity. This includes the vital capacity and the residual volume. It is approximately 6000mL. TLC=VC+RV
- **Minute Respiratory Volume** The amount of air that moves into the respiratory passage per minute is called minute respiratory volume.

  Normal TV = 500mL; Normal respiratory rate = 12 times/minute
  Therefore, minute respiratory volume = 6 Litres/minute (for a normal healthy man).

Dead space

Some of the inspired air never reaches the gas exchange areas but fills the respiratory passages where exchange of gases does not occur. This air is called dead space.

Dead space is not involved in gaseous exchange. It amounts to approximately 150mL.

6.4 Exchange of gases

The primary site for the exchange of gases is the alveoli. The uptake of O_2 and the release of CO_2 occur between the blood and tissues by simple diffusion driven by partial pressure gradient of O_2 and CO_2. Partial pressure is the pressure contributed by an individual gas in a mixture of gases. It is represented as pO_2 for oxygen and pCO_2 for carbon–

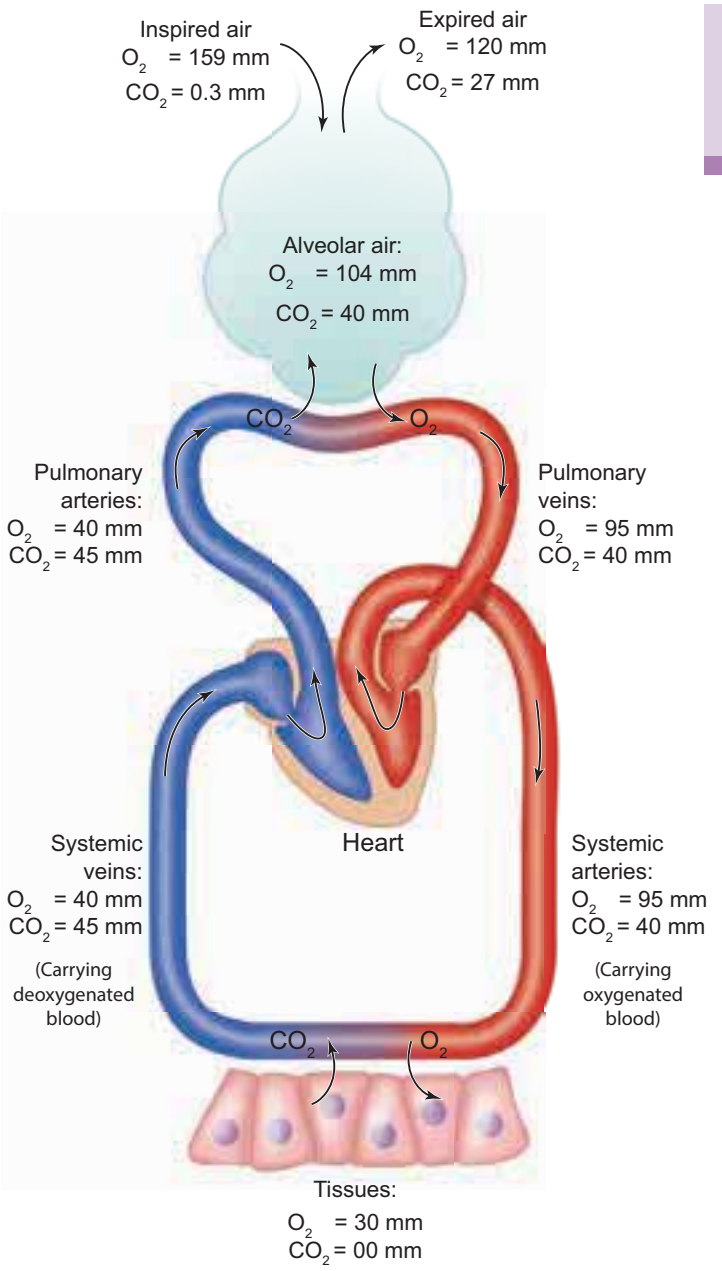


Figure 6.6 Exchange of gases at the alveolus and the tissue with blood and transport of oxygen and carbondioxide

Breathing through nose is healthier than through mouth– Why?

dioxide. Due to pressure gradients, O_2 from the alveoli enters into the blood and reaches the tissues. CO_2 enters into the blood from the tissues and reaches alveoli for elimination. As the solubility of CO_2 is 20–25 times higher than that of O_2, the partial pressure of CO_2 is much higher than that of O_2 (Tab.6.1 and Figure 6.6).

Respiratory pigments

Haemoglobin

Haemoglobin belongs to the class of conjugated protein. The iron containing pigment portion haem constitutes only 4% and the rest colourless protein of the histone class globin. Haemoglobin has a molecular weight of 68,000 and contains four atoms of iron, each of which can combine with a molecule of oxygen.

Methaemoglobin

If the iron component of the haem moieties is in the ferric state, than the normal ferrous state, it is called methaemoglobin. Methaemoglobin

Respiratory gases	Partial pressure mm Hg				
	Atmospheric air	Alveoli	Deoxygenated Blood	Oxygenated blood	Tissues
O_2	159	104	40	95	40
CO_2	0.3	40	45	40	45

Table 6.1 Partial pressure of Oxygen and Carbon dioxide (in mmHg) in comparison to those gases in the atmosphere

does not bind O_2. Normally RBC contains less than 1% methaemoglobin.

6.5 Transport of gases

6.5.1 Transport of oxygen

Molecular oxygen is carried in blood in two ways: bound to haemoglobin within the red blood cells and dissolved in plasma. Oxygen is poorly soluble in water, so only 3% of the oxygen is transported in the dissolved form. 97% of oxygen binds with haemoglobin in a reversible manner to form oxyhaemoglobin (HbO_2). The rate at which haemoglobin binds with O_2 is regulated by the partial pressure of O_2. Each haemoglobin carries maximum of four molecules of oxygen. In the alveoli high pO_2, low pCO_2, low temperature and less H^+ concentration, favours the formation of oxyhaemoglobin, whereas in the tissues low pO2, high pCO_2, high H^+ and high temperature favours the dissociation of oxygen from oxyhaemoglobin.

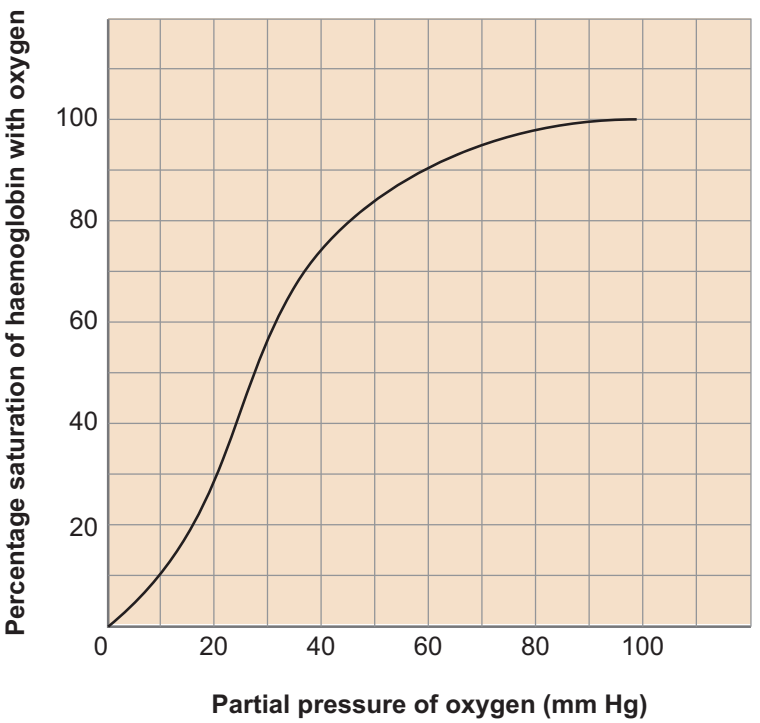


Figure 6.7 Oxygen dissociation curve

A sigmoid curve (S–shaped) is obtained when percentage saturation of haemoglobin with oxygen is plotted against pO_2. This curve is called oxygenhaemoglobin dissociation curve (Figure 6.7). This S–shaped curve has a steep slope for pO_2 values between 10 and 50mmHg and then flattens between 70 and 100 mm Hg.

Under normal physiological conditions, every 100mL of oxygenated blood can deliver about 5mL of O_2 to the tissues.

6.5.2 Transport of Carbon–dioxide

Blood transports CO_2 from the tissue cells to the lungs in three ways

i. **Dissolved in plasma** About 7 – 10% of CO_2 is transported in a dissolved form in the plasma.

ii. **Bound to haemoglobin** About 20 – 25% of dissolved CO_2 is bound and carried in the RBCs as carbaminohaemoglobin (Hb CO_2)

$$CO_2 + Hb \rightleftharpoons Hb\ CO_2$$

iii. **As bicarbonate ions in plasma** about 70% of CO_2 is transported as bicarbonate ions

This is influenced by pCO_2 and the degree of haemoglobin oxygenation. RBCs contain a high concentration of the enzyme, carbonic anhydras, Whereas small amounts of carbonic anhydrase is present in the plasma.

At the tissues the pCO_2 is high due to catabolism and diffuses into the blood to form HCO_3^- and H^+

ions. When CO_2 diffuses into the RBCs, it combines with water forming carbonic acid (H_2CO_3) catalyzed by carbonic anhydrase. Carbonic acid is unstable and dissociates into hydrogen and bicarbonate ions.

Carbonic anhydrase facilitates the reaction in both directions.

$$CO_2 + H_2O \underset{}{\overset{\text{carbonic anhydrase}}{\rightleftharpoons}} H_2CO_3$$

$$\overset{\text{carbonic anhydrase}}{\rightleftharpoons} HCO_3^- + H^+$$

The HCO_3– moves quickly from the RBCs into the plasma, where it is carried to the lungs. At the alveolar site where pCO_2 is low, the reaction is reversed leading to the formation of CO_2 and water. Thus CO_2 trapped as HCO_3^- at the tissue level it is

Events in inspiration and expiration

Inspiration	Expiration
Respiratory centre initiates the stimuli during inspiration. ↓ Impulses are carried to the inspiratory muscles through nerves. ↓ Diaphragm and inspiratory muscles contract. ↓ The thoracic volume increases as the chest wall expands. ↓ The intra pulmonary pressure is reduced. ↓ The alveolar pressure decreases than the atmospheric pressure ↓ Air flows into the alveoli until the alveolar pressure equalizes the atmospheric pressure and the alveoli get inflated.	Respiratory centre terminates the stimuli during expiration. ↓ The diaphragm and inspiratory muscles relax. ↓ Chest wall contracts and the thoracic volume gets reduced. ↓ The intra pulmonary pressure is reduced. ↓ The alveolar pressure increases than the atmospheric pressure. ↓ Air is sent out due to the contraction of alveoli. ↓ Air flows out of the alveoli until the alveolar pressure equalizes the atmospheric pressure and the alveoli get deflated.

transported to the alveoli and released out as CO_2. Every 100mL of deoxygenated blood delivers 4mL of CO_2 to the alveoli for elimination.

Bohr effect and Haldane effect

Increase in pCO_2 and decrease in pH decrease the affinity of haemoglobin for oxygen and shifts the oxyhaemoglobin dissociation curve to the right and facilitates unloading of oxygen from hemoglobin in the tissue. This effect of pCO_2 and pH on the oxyhaemoglobin dissociation curve is called the Bohr small effect.

The Haldane effect, on the other hand describes how oxygen concentrations determines hemoglobin's affinity for carbon dioxide. The amount of carbon dioxide transported in blood is remarkably affected by the degree oxygenation of the blood. The lower the partial pressure of O_2 lower is the affinity of haemoglobin saturation with oxygen hence more CO_2 is carried in the blood. This phenomenon is called Haldane effect. This effects CO_2 exchanges in both the tissues and lungs.

In the lungs the process is reversed as the blood moves through the pulmonary capillaries, its pCO_2 declines from 45mm Hg to 40mm Hg. For this to occur carbondioxide is freed from HCO_3^- ions and Cl^- ions moves in to the plasma and reenters the RBC and binds with H^+ to form carbonic acid which dissociates in to CO_2 and water. This CO_2 diffuses along its partial gradient from the blood to the alveoli (Figure 6.8).

6.6 Regulation of Respiration

A specialised respiratory centre present in the medulla oblongata of the hind brain called respiratory rhythm centre

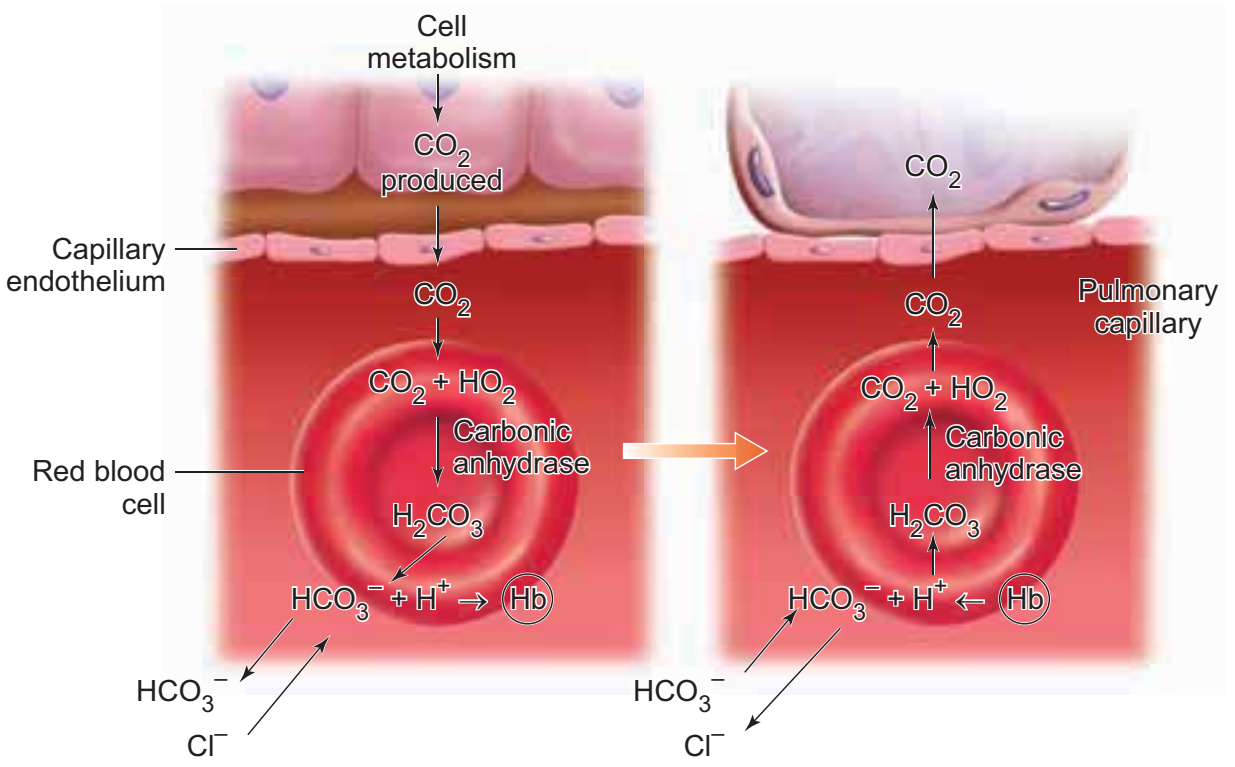


Figure 6.8 Chloride shift mechanism

Particulate matter PM 2.5 in the air is increasing day by day which causes respiratory illness. Central Pollution Control Board (CPCB) reports that the quality of air is not good due to soot and smoke. So some cities in India are using CNG (Compressed Natural Gas) as fuel.

is responsible for this regulation. Pneumotaxic centre present in pons varoli region of the brain moderates the function of the respiratory rhythm centre to ensure normal breathing. The chemosensitive area found close to the rhythm centre is highly sensitive to CO_2 and H^+. And H^+ are eliminated out by respiratory process. Receptors associated with the aortic arch and carotid artery send necessary signals to the rhythm centre for remedial action. The role of O_2 is insignificant in the regulation of respiratory rhythm.

6.7 Problems in Oxygen transport

When a person travels quickly from sea level to elevations above 8000ft, where the atmospheric pressure and partial pressure of oxygen are lowered, the individual responds with symptoms of acute mountain sickness (AMS)–headache, shortness of breath, nausea and dizziness due to poor binding of O_2 with haemoglobin. When the person moves on a long–term basis to mountains from sea level is body begins to make respiratory and haematopoietic adjustments. To overcome this situation kidneys accelerate production of the hormone erythropoietin, which stimulates the bone marrow to produce more RBCs.

When a person descends deep into the sea, the pressure in the surrounding water increases which causes the lungs to decrease in volume. This decrease in volume increases the partial pressure of the gases within the lungs. This effect can be beneficial, because it tends to drive additional oxygen into the circulation, but this benefit also has a risk, the increased pressure can also drive nitrogen gas into the circulation. This increase in blood nitrogen content can lead to a condition called **nitrogen narcosis.** When the diver ascends to the surface too quickly a condition called 'bends' or decompression sickness occurs and nitrogen comes out of solution while still in the blood forming bubbles. Small bubbles in the blood are not harmful, but large bubbles can lodge in small capillaries, blocking blood flow or can press on nerve endings. Decompression sickness is associated with pain in joints and muscles and neurological problems including stroke. The risk of nitrogen narcosis and bends is common in scuba divers.

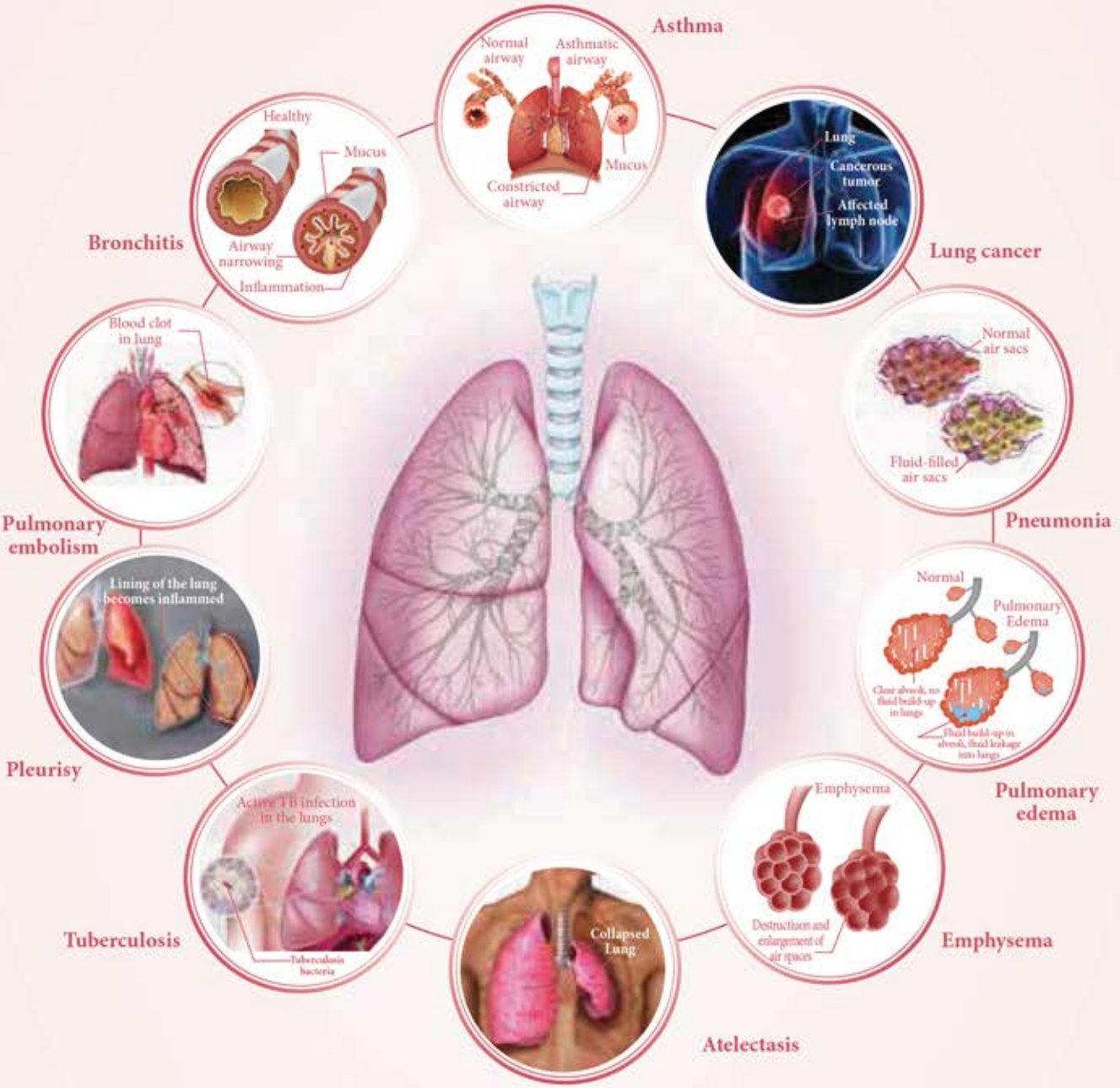
During carbon–dioxide poisoning, the demand for oxygen increases. As the O_2 level in the blood decreases it leads

DO YOU KNOW?

Allergy is caused by allergens. When we enter a polluted area, immediately we start sneezing and coughing. The allergens in that place affect our respiratory tracts and the responses to the allergens start within minutes. Allergens provoke an inflammatory response. A common manifestation of allergy is Asthma.

Disorders of Respiratory System

Respiratory system is highly affected by environmental, occupational, personal and social factors. These factors may be responisble for a number of respiratory disorders.



- **Pulmonary embolism** is a blood clot that occurs in the lungs.
- **Bronchitis** is an inflammation of the lining of your bronchial tubes.
- **Asthma** is a condition in which airways narrow and swell and produce extra mucus.
- **Lung cancer** -The number one cause of cancer deaths. Smoking is the risk factor for lung cancer.
- **Pneumonia** is an inflammatory condition of the lung affecting primarily the small air sacs known as alveoli.
- **Pulmonary edema** is a fluid accumulation in the tissue and air spaces of the lungs.
- **Emphysema** A lung condition that causes shortness of breath due to widening of alveoli.
- **Atelectasis** is a collapse of a lung or lobe of a lung develops when alveoli within the lung become deflated.
- **Tuberculosis** is an infectious disease caused due to *Mycobacterium tubuerculae*.
- **Pleurisy** is a condition in which the pleura becomes inflamed.

to suffocation and the skin turns bluish black.

6.8 Disorders of the Respiratory system

Respiratory system is highly affected by environmental, occupational, personal and social factors. These factors may be responsible for a number of respiratory disorders. Some of the disorders are discussed here.

Asthma – It is characterized by narrowing and inflammation of bronchi and bronchioles and difficulty in breathing. Common allergens for asthma are dust, drugs, pollen grains, certain food items like fish, prawn and certain fruits etc.

Emphysema– Emphysema is chronic breathlessness caused by gradual breakdown of the thin walls of the alveoli decreasing the total surface area of a gaseous exchange. i.e., widening of the alveoli is called emphysema. The major cause for this disease is cigarette smoking, which reduces the respiratory surface of the alveolar walls.

Bronchitis– The bronchi when it gets inflated due to pollution smoke and cigarette smoking, causes bronchitis. The symptoms are cough, shortness of breath and sputum in the lungs.

Pneumonia– Inflammation of the lungs due to infection caused by bacteria or virus is called pneumonia. The common symptoms are sputum production, nasal congestion, shortness of breath, sore throat, etc.

Tuberculosis– Tuberculosis is caused by *Mycobacterium tuberculae*. This infection mainly occurs in the lungs and bones. Collection of fluid between the lungs and the chest wall is the main complication of this disease.

Occupational respiratory disorders– The disorders due to one's occupation of working in industries like grinding or stone breaking, construction sites, cotton industries, etc. Dust produced affects the respiratory tracts.

Long exposure can give rise to inflammation leading to fibrosis. Silicosis and asbestosis are occupational respiratory diseases resulting from inhalation of particle of silica from sand grinding and asbestos into the respiratory tract. Workers, working in such industries must wear protective masks.

6.9 Effects of Smoking

Today due to curiosity, excitement or adventure youngsters start to smoke and later get addicted to smoking. Research says about 80% of the lung cancer is due to cigarette smoking.

Smoking is inhaling the smoke from burning tobacco. There are thousands of known chemicals which includes nicotine, tar, carbon monoxide, ammonia, sulphur–dioxide and even small quantities of arsenic. Carbon monoxide and nicotine damage the cardiovascular system and tar damages the gaseous exchange system. Nicotine is the chemical that causes

Sumanan noticed that his close friend was addicted to cigarette smoking. He advised his friend and explained the ill–effects of smoking. As a Biology student, explain what advice he might have given to his friend regarding the ill–effects of smoking.

addiction and is a stimulant which makes the heart beat faster and the narrowing of blood vessels results in raised blood pressure and coronary heart diseases. Presence of carbon monoxide reduces oxygen supply. Lung cancer, cancer of the mouth and larynx is more common in smokers than non–smokers. Smoking also causes cancer of the stomach, pancreas and bladder and lowers sperm count in men.

Smoking can cause lung diseases by damaging the airways and alveoli and results in emphysema and chronic bronchitis. These two diseases along with asthma are often referred as Chronic Obstructive Pulmonary Disease (COPD). When a person smokes, nearly 85% of the smoke released is inhaled by the smoker himself and others in the vicinity, called passive smokers, are also affected. Guidance or counselling should be done in such users to withdraw this habit.

AMAZING FACTS

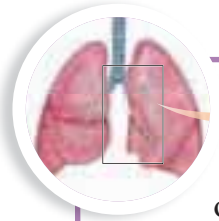
- The World TB Day is March 24.
- Direct Observation Therapy (DOTs) can treat about 95% of the TB patients.
- The surface area of the lungs is roughly the same size as a tennis court (525 feet long).
- It is possible to live with one lung.
- The highest recorded 'sneeze speed' is 165 km per hour.
- Adults breathe around 12 – 16 times per minute where as new borns breathe around 30–60 times per minute.
- Yawning helps us to breathe more oxygen to the lungs. When our brain senses the shortage of O_2, it send a message to CNS to imbalance to O_2 demand and trigger us to yawn.
- Breathing through mouth results in bladder shrinkage and creates an urge to urinate in the middle of the night.
- Most people can hold their breath between 30 seconds to one minute.
- Hiccups are due to eating too fast or having occasional spasms of the diaphragm.

Activity

To test the presence of CO_2 in exhaled air Take two test tubes A and B with few mL of clear lime water. Blow exhaled air into A with a help of a straw and pass normal air into B with a help of a syringe for about 15 times and observe the changes that occur in the tubes A and B. The lime water (Calcium Hydroxide) in the test tube A turns milky.

ICT Corner

Respire



Let's explore the anatomy and function of the **Respiratory system.**

Step – 1

Use the URL to reach the 'Respiratory System' page. In the grid select 'Nasal cavity' and explore its structure and the functions.

Step – 2

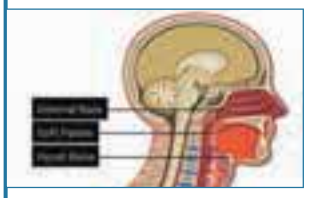
Now click back button on the top of the window or use the 'Backspace' key. Select 'Pharynx' from the grid and explore its anatomical regions.

Step – 3

Follow the above steps to explore each part and its functions.

Step – 4

Use the reference given below the page to acquire additional details.



Step 1

Step 2

Step 3

Step 4

Respiratory System's URL:

https://www.getbodysmart.com/respiratory-system

Schematics of Gas exchange:

https://www.wisc-online.com/learn/general-education/anatomy-and-physiology2/ap2404/respiratory-system-gas-exchange

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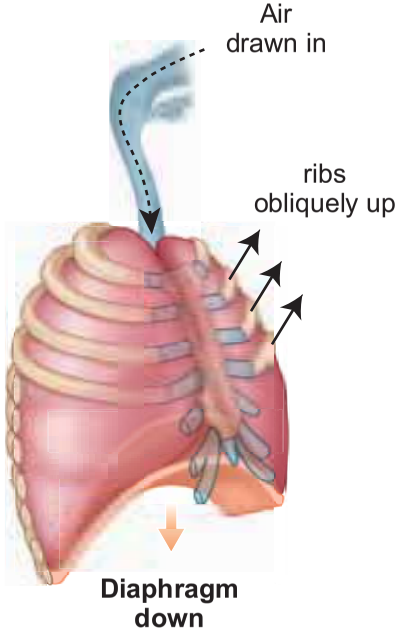
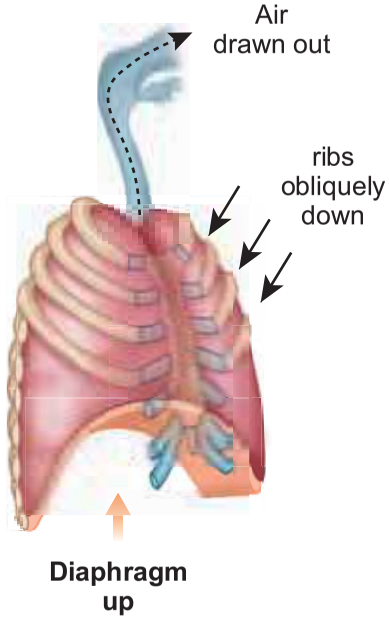
* Pictures are indicative only

Concept map

Mechanism of Respiration

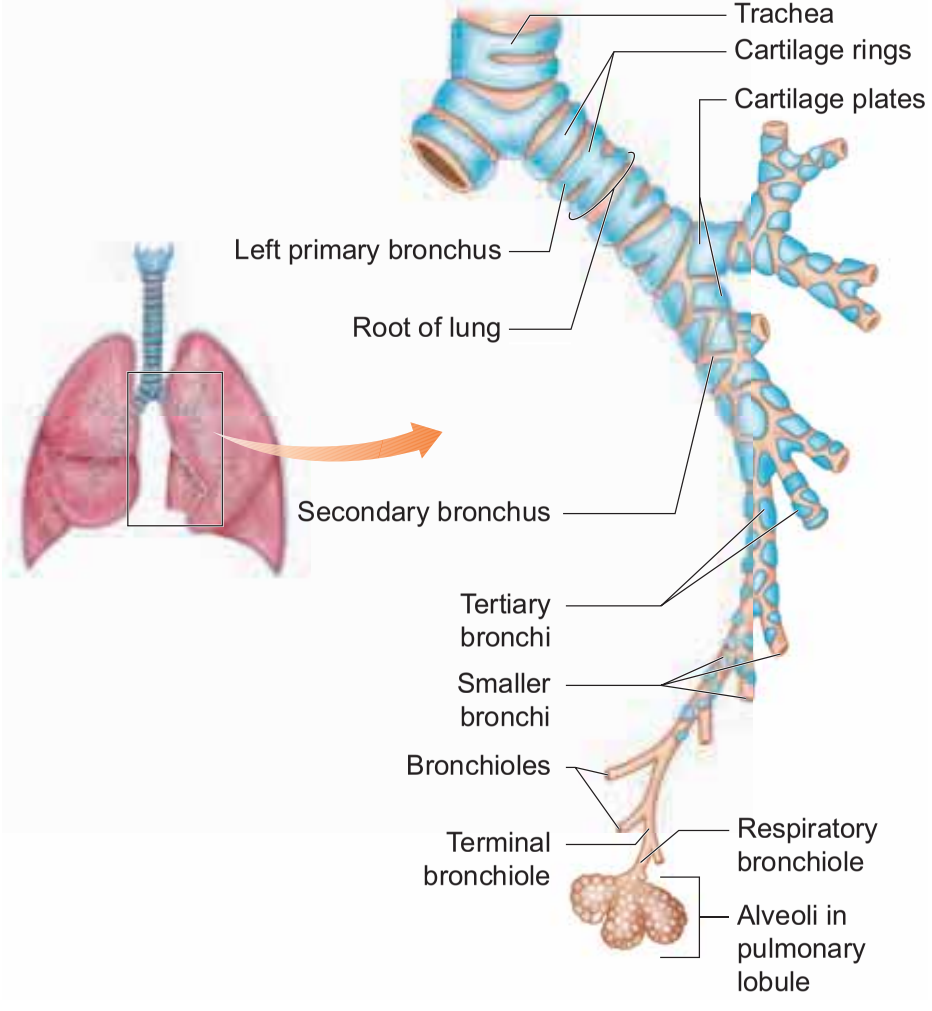
- Inspiration and Expiration happens due to pressure changes in the thoracic cavity.
- By the contraction and expansion of diaphragm, external intercostal muscles and internal intercostal muscles the volume of the thoracic cavity is reduced or increased.
- The act of breathing is performed by expansion and contraction of the thoracic cavity.
- **INSPIRATION**
  - An active process by which fresh air is drawn into the lungs.
  - The contraction of external intercostal muscle causes the ribs to move anteriorly and outwardly.
  - The contraction of the diaphragm leads to flattening of inelastic, dome shaped central part of the diaphragm.
- **EXPIRATION**
  - A passive process by which air is exhaled from the lungs.
  - The diaphragm relaxes and rises to resume its original dome shape.
  - The ribs take their original position as a result of contraction of the internal intercostal muscles.





Respiratory system

- Nose
- Nasal & oral cavities
- Pharynx
- Larynx
- Trachea
- Bronchi
  - Secondary bronchi
  - Tertiary bronchi
  - Smaller bronchi
  - Bronchioles
  - Terminal bronchiole
  - Respiratory bronchiole
  - Alveoli
    - Alveoli walls: single layer of simple squamous epithelium – maximal surface area and minimal diffusion distance.



Summary:

The process of intake of oxygen rich air and giving out of air rich in carbon dioxide is generally called respiration. Pollutants and micro organism are filtered from the inspired air by the hair and mucus present in the nostrils. The two main steps in the mechanism of respiration are inspiration and expiration which takes place due to pressure gradient in the atmosphere and lungs.

O_2 is transported in blood in dissolved form and is also bound to haemoglobin. One molecule of haemoglobin can bind four molecules of O_2. The Sigmoid shape of the O_2 haemoglobin dissociative curve shows increased affinity for each O_2 molecule.

CO_2 is transported in blood in dissolved form as carbamino haemoglobin and as HCO_3. HCO_3 is produced in RBCs from CO_2 and water catalysed by carbonic anhydrase. Breathing is controlled by medullary respiratory centre.

Respiratory volumes and capacities indicate the amount of air inspired and expired during normal respiration. Our respiratory system can be affected by pollutants, pathogens and other chemical substances found in air. Lung cancer and emphysema cannot be cured and these diseases are common among cigarette smokers.

People at higher level than the sea level are prompted to altitude sickness as the barometric pressure is low in those regions. Surfactant, emphysema, Asthma and Dead space have been discussed. During vigorous exercise the rate of respiration increases.

Glossary

Apnoea – Temporary stopping of respiration.

Book gills – Respiratory organs in aquatic Limulus.

Book lungs – Respiratory organs of Scorpions and most spiders.

COLD – Chronic Obstructive Lung Disease.

Dyspnoea – painful respiration.

Epiglottis – a thin elastic cartilaginous flap which covers the glottis and prevents the entry of food into the larynx.

Haemoglobin – iron containing red pigment of RBCs of vertebrates, gives red colour to blood.

Herring-Breuer reflex – a defensive mechanism against over dilation of lungs.

Hypoxia – the failure of tissues for any reason to receive an adequate supply of oxygen.

Pneumothorax – presence of air in the pleural cavity which causes collapsing of lungs.

Vocal cords – sound regulating cords also called larynx or voice box.

Yawning – prolonged inspiration due to increase in CO_2 concentration.

Evaluation

1. Breathing is controlled by
   a. cerebrum
   b. medulla oblongata
   c. cerebellum
   d. pons
2. Intercostal muscles are found between the
   a. vertebral column
   b. sternum
   c. ribs
   d. glottis
3. The respiratory structures of insects are
   a. tracheal tubes
   b. gills
   c. green glands
   d. lungs
4. Asthma is caused due to
   a. bleeding in pleural cavity.
   b. infection of nose
   c. damage of diaphragm.
   d. infection of lungs
5. The Oxygen Dissociation Curve is
   a. sigmoid
   b. straight line
   c. curved
   d. rectangular hyperbola
6. The Tidal Volume of a normal person is
   a. 800 mL
   b. 1200 mL
   c. 500 mL
   d. 1100 – 1200 mL
7. During inspiration, the diaphragm
   a. expands.
   b. unchanged
   c. relaxes to become domed–shaped.
   d. contracts and flattens
8. CO_2 is transported through blood to lungs as
   a. carbonic acid
   b. oxyhaemoglobin
   c. carbamino haemoglobin
   d. carboxy haemoglobin
9. When 1500 mL air is in the lungs, it is called
   a. vital capacity
   b. tidal volume
   c. residual volume
   d. inspiratory reserve volume
10. Vital capacity is
    a. TV + IRV
    b. TV + ERV
    c. RV + ERV
    d. TV + TRV + ERV
11. After a long deep breath, we do not respire for some seconds due to
    a. more CO_2 in the blood
    b. more O_2 in the blood
    c. less CO_2 in the blood
    d. less O_2 in the blood
12. Which of the following substances in tobacco smoke damage the gas exchange system?
    a. carbon monoxide and carcinogens
    b. carbon monoxide and nicotine
    c. carcinogens and tar
    d. nicotine and tar

13. Column I represents diseases and column II represents their symptoms. Choose the correctly paired option

Column I	Column II
(P) Asthma	(i) Recurring of bronchitis
(Q) Emphysema	(ii) Accumulation of W.B.CS in alveolus
(R) Pneumonia	(iii) Allergy

a. P = iii, Q = ii, R = i
b. P = iii, Q = i, R = ii
c. P = ii, Q = iii, R = i
d. P = ii, Q = i, R = iii

14. Which of the following best describes the process of gas exchange in the lungs?
   a. Air moves in and out of the alveoli during breathing.
   b. Carbon dioxide diffuses from deoxygenated blood in capillaries into the alveolar air.
   c. Oxygen and carbon dioxide diffuse down their concentration gradients between blood and alveolar air.
   d. Oxygen diffuses from alveolar air into deoxygenated blood.

15. Make the correct pairs.

Columan–I	Column–II
(P) IC	i. maximum volume of air breathe in after forced.
(Q) EC	ii. Volume of air present after expiration in lungs.
(R) VC	iii. Volume of air inhaled after expiration.
(S) FRC	iv. Volume of air exhaled after inspiration.

(a) P – i , Q – ii , R – iii , S – iv
(b) P – ii , Q – iii , R – iv , S – i
(c) P – ii , Q – iii , R – i , S – iv
(d) P – iii , Q – iv , R – i , S – ii

16. Make the correct pairs.

Columan–I	Column–II
(P) Tidal volume	i. 1000 to 1100 ml
(Q) Residual volume	ii. 500 ml
(R) Expiratory reserve volume	iii. 2500 to 3000 ml
(S) Inspiratory reserve volume	iv. 1100 to 1200 ml

(a) P – ii , Q – iv , R – i , S – iii
(b) P – iii , Q – ii , R – iv , S – i
(c) P – ii , Q – iv , R – iii , S – i
(d) P – iii , Q – iv , R – i , S – ii

17. Name the respiratory organs of flatworm, earthworm, fish, prawn, cockroach and cat.
18. Name the enzyme that catalyses the bicarbonate formation in RBCs.
19. Air moving from the nose to the trachea passes through a number of structures. List in order of the structures.
20. Which structure seals the larynx when we swallow?
21. Resistance in the airways is typically low. Why? Give two reasons.
22. How the body makes long–term adjustments when living in high altitude.

23. Diffusion of gases occurs in the alveolar region only and not in any other part of the respiratory system. Discuss.
24. Sketch a flow chart to show the path way of air flow during respiration.
25. Why is pneumonia considered a dangerous disease?
26. Explain the conditions which creates problems in oxygen transport.

Competitive Exam Corner

Sarojini's father has congestion of the lungs. His doctor advised him to take bedrest and prescribed him an inhaler. What disease is he is suffering from? List the symptoms for the disease.

A villager who came to the city was affected by severe respiratory illness due to the inhalation of particulate pollutants. Suggest the reason for his illness and how does particulate pollutants affect him.

Kumar's mother works in a stone grinding factory. Suddenly she faints and taken to the hospital. The doctor notices fibres in the lungs. What kind of disease is she affected with? How can it be rectified?

Web links

http://kidshealth.org/kid/closet/movies/how_the_body_works_interim.html

References

1. Guyton A.C. and Hall. J. E, (2006) Textbook of Medical Physiology– Eleventh Edition Elsevier Saunders, International Edition ISBN 0–8089–2317–X.
2. Mackean D.G. and Hayward D (2014). AS and A level biology book, Cambridge International, 3rd edition, Hodder Education, An Hachette UK company, London NWI 3BH.
3. Dee Unglaub Silverthron, Human physiology –an integrated approach – 7th Edition – Pearson Global edition.
4. Elaine N. Marieb and Katja Hoehn (2010). Human Anatomy and Physiology Eighth Edition, Benjamin Cummings, Pearson. New York.
5. Lauralee Sherwood and Robert kell. (2007). Human physiology from cells to systems. First Canadian Edition Nelson Education Ltd, Toronto, Ontario MIK SG4.
6. Moyes and Schulte, 2016 Principles of Animal Physiology– 2 nd edition, Pearson
7. Muthayya N.M., 2010 Human physiology– 4th edition, Jaypee brother medical publishers.

UNIT III **Chapter 7**

Body Fluids and Circulation

Stroke volume is dependent on venous return

Chapter Outline

Learning Objectives:

- *Understands the importance of body fluids.*
- *Identifies and describes the blood cells, different types of blood groups and blood coagulating factors.*
- *Differentiate the blood vessels and its properties*
- *Understands the human circulatory system.*
- *Understands the cardiac cycle and relate with the peaks of ECG.*
- *Identifies the disorders of circulatory system.*

6L4CBH

Animals particularly larger animals like mammals, are more active. They depend on locomotion to find food which is an energy consuming process. Nervous system is required to coordinate activities by sending nerve impulses that involves energy. All living cells have to be supplied with nutrients, oxygen and other substances and have to remove CO_2 and waste products from them. It is therefore essential to have efficient mechanisms for transport of these substances to and from the cells. Different groups of animals have evolved different methods of transport. Very small organisms like the sponges and coelenterates lack a circulatory system. Water from their surroundings enters their body cavity to facilitate the cells to exchange substances by diffusion. More complex organisms use special fluids and well organized transport systems within their body to transport such materials by **bulk flow** or connective transport with pumps. The phenomenon of bulk flow is fundamental to many

physiological processes like respiration, digestion and excretion. The bulk flow of fluids can transport substances to long distances faster than by diffusion. The human circulatory system can circulate a millilitre of blood from the heart to feet and back again within 60 sec, rather than 60 years which may be needed if it were by diffusion.

Within our body the transport system helps in the coordination of physiological processes by transporting chemical signals from one place to another and assisting in the defence of the body by transporting immune cells to the sites of infection. These processes contribute to overall homeostasis (maintenance of constant internal environment). Movement of respiratory gases, hormones, nutrients, wastes and heat are carried by the circulatory system as shown in Figure 7.1.

Oxygen and carbon dioxide are exchanged in the lungs and tissues whereas nutrients from the digestive system are carried to the liver and the wastes from the tissues are carried by the blood and finally removed by the kidneys. The hormones are transported to their target organs. Circulatory system helps to maintain the homeostasis of the body fluids and body temperature (heat exchange).

The homeostatic regulation of the cardio vascular system maintains blood flow, or perfusion, to the heart and brain. In vasovagal syncope (fainting), signals from the nervous system cause a sudden decrease in blood pressure, and the individual faints from lack of oxygen to the brain.

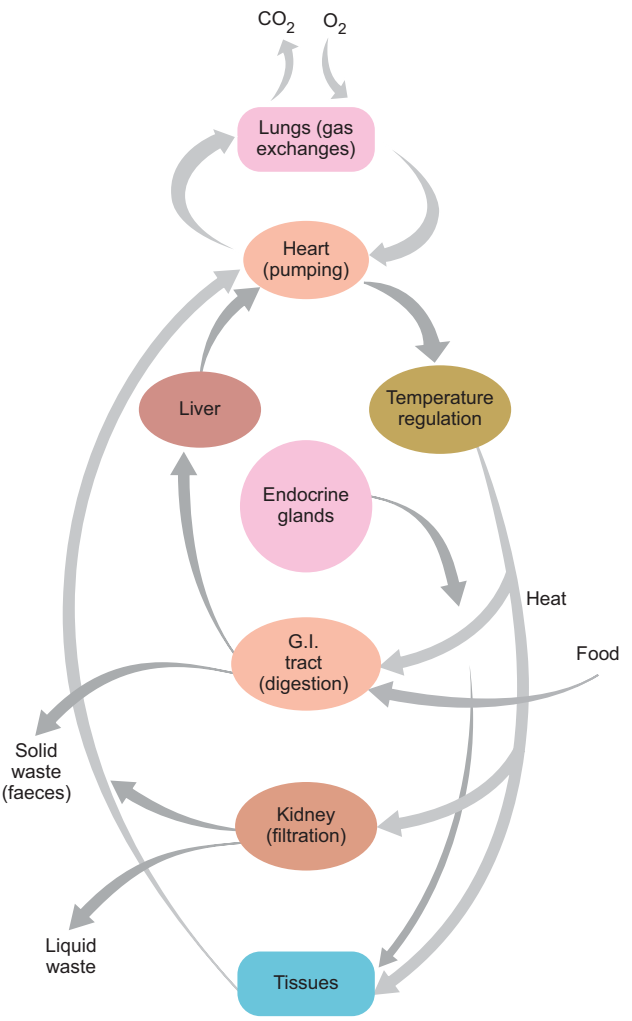


Figure 7.1 Schematic representations of the major functions of the circulatory system

In this chapter you will learn how the heart and blood vessels work together most of the time to prevent such problems.

7.1 Body fluids

The body fluid consists of water and substances dissolved in them. There are two types of body fluids, the intracellular fluid present inside the cells and the extracellular fluid present outside the cells. The three types of extracellular fluids are the **interstitial fluid** or tissue fluid (surrounds

the cell), the **plasma** (fluid component of the blood) and lymph. The blood flowing into the capillary from an arteriole has a high hydrostatic pressure. This pressure is brought about by the pumping action of the blood and it tends to force water and small molecules out through the permeable walls of the capillary into the tissue fluid.

The volume of fluid which leaves the capillary to form tissue fluid is the result of two opposing pressures. The water potential is lesser than hydrostatic pressure inside the capilary bed which is enough to push fluid into the tissues. The tissue fluid has low concentration of protien than that of plasma. At the venous end of the capillary bed, the water potential is greater than the hydrostatic pressure and the fluid from the tissues flows into the capillary and water is drawn back into the blood, taking with it waste products produced by the cells.

Composition of Blood

Blood is the most common body fluid that transports substances from one part of the body to the other. Blood is a connective tissue consisting of plasma (fluid matrix) and formed elements. The plasma constitutes 55% of the total blood volume. The remaining 45% is the formed elements that consist of blood cells. The average blood volume is about 5000ml (5L) in an adult weighing 70 Kg.

7.1.1 Plasma

Plasma mainly consists of water (80-92%) in which the plasma proteins, inorganic constituents (0.9%), organic constituents (0.1%) and respiratory gases are dissolved. The four main types of plasma proteins synthesized in the liver are albumin, globulin, prothrombin and fibrinogen. **Albumin** maintains the osmotic pressure of the blood. **Globulin** facilitates the transport of ions, hormones, lipids and assists in immune function. Both **Prothrombin** and **Fibrinogen are** involved in blood clotting. **Organic constituents** include urea, amino acids, glucose, fats and vitamins; and the **inorganic constituents** include chlorides, carbonates and phosphates of potassium, sodium, calcium and magnesium. The composition of plasma is not always constant. Immediately after a meal, the blood in the hepatic portal vein has a very high concentration of glucose as it is transporting glucose from the intestine to the liver where it is stored. The concentration of the glucose in the blood gradually falls after sometime as most of the glucose is absorbed. If too much of protein is consumed, the body cannot store the excess amino acids formed from the digestion of proteins. The liver breaks down the excess amino acids and produces urea. Blood in the hepatic vein has a high concentration of urea than the blood in other vessels namely, hepatic portal vein and hepatic artery.

Liver receives its blood supply from two sources: the hepatic artery brings oxygenated blood from the heart, while the hepatic portal vein brings blood from the intestine and other abdominal organs. The blood is returned from the liver to the heart by the hepatic veins.

7.1.2 Formed elements

Red blood cells/corpuscles (erythrocytes), white blood cells/corpuscles (Leucocytes) and platelets are collectively called formed elements.

Red blood cells

Red blood cells are abundant than the other blood cells. There are about 5 million to 5.5 millions of RBC mm^{-3} of blood in a healthy man and 4.5-5.0 millions of RBC mm^{-3} in healthy women. The RBCs are very small with the diameter of about 7μm (micrometer). The structure of RBC is shown in Figure 7.2. The red colour of the RBC is due to the presence of a respiratory pigment, haemoglobin dissolved in the cytoplasm. Haemoglobin plays an important role in the transport of respiratory gases and facilitates the exchange of gases with the fluid outside the cell (tissue fluid). The biconcave shaped RBCs increases the surface area to volume ratio, hence oxygen diffuses quickly in and out of the cell. The RBCs are devoid of nucleus, mitochondria, ribosomes and endoplasmic reticulum. The absence of these organelles accommodates more haemoglobin thereby maximising the oxygen carrying capacity of the cell. The average life span of RBCs in a healthy individual is about 120 days after which they are destroyed in the spleen (graveyard / cemetery of RBCs) and the iron component returns to the bone marrow for reuse. Erythropoietin is a hormone secreted by the kidneys in response to low oxygen and helps in differentiation of stem cells of the bone marrow to erythrocytes (erythropoiesis) in adults. The ratio of red blood cells to blood plasma is expressed as **Haematocrit** (packed cell volume).

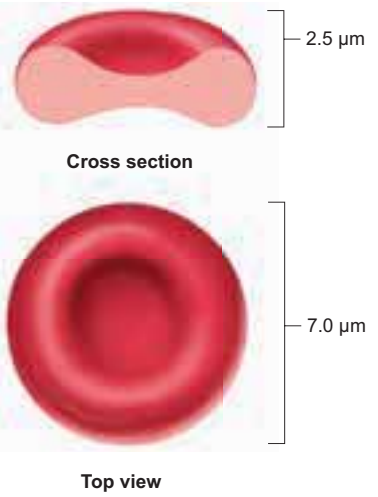


Figure 7.2 Structure of RBC

White blood cells (leucocytes) are colourless, amoeboid, nucleated cells devoid of haemoglobin and other pigments. Approximately 6000 to 8000 per cubic mm of WBCs are seen in the blood of an average healthy individual. The different types of WBCs are shown in Figure 7.3. Depending on the presence or absence of granules, WBCs are divided into two types, granulocytes and agranulocytes. Granulocytes are characterised by the presence of granules in the cytoplasm and are differentiated in the bone marrow. The granulocytes include neutrophils, eosinophils and basophils.

Neutrophils are also called heterophils or polymorphonuclear (cells with 3-4 lobes of nucleus connected with delicate threads) cells which constitute about 60%- 65% of the total WBCs. They are phagocytic in nature and appear in large numbers in and around the infected tissues.

Eosinophils have distinctly bilobed nucleus and the lobes are joined by thin

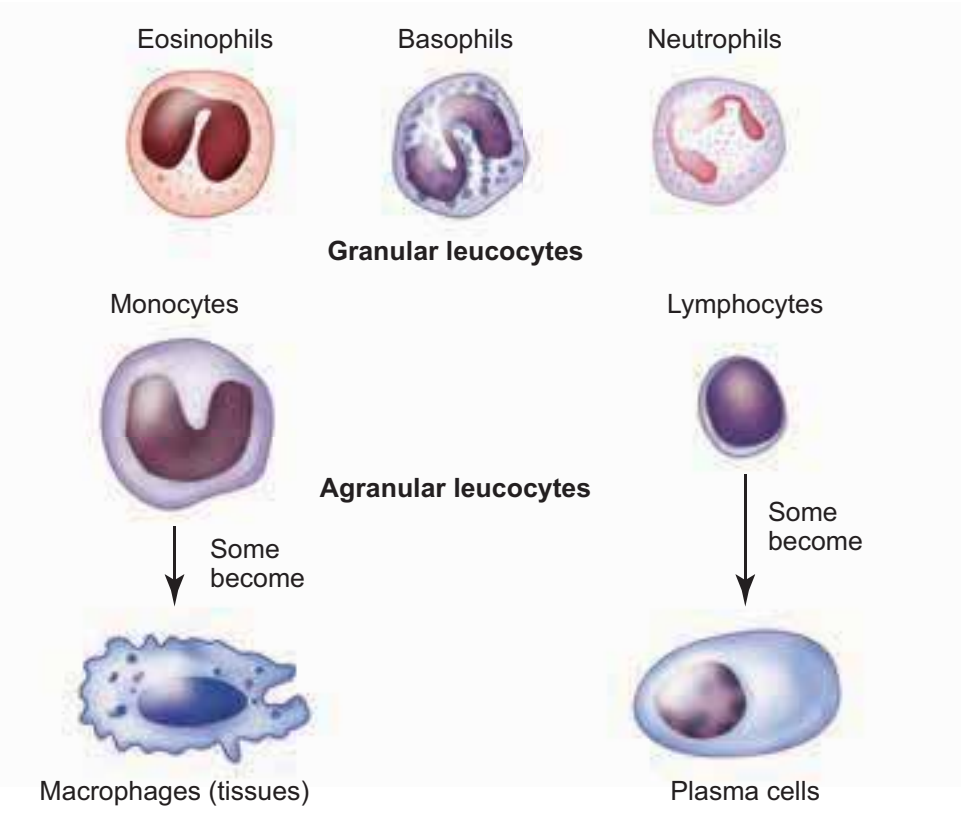


Figure 7.3 Different types of WBC

strands. They are non-phagocytic and constitute about 2-3% of the total WBCs. Eosinophils increase during certain types of parasitic infections and allergic reactions.

Basophils are less numerous than any other type of WBCs constituting 0.5%-1.0% of the total number of leucocytes. The cytoplasmic granules are large sized, but fewer than eosinophils. Nucleus is large sized and constricted into several lobes but not joined by delicate threads. Basophils secrete substances such as heparin, serotonin and histamines. They are also involved in inflammatory reactions.

Agranulocytes are characterised by the absence of granules in the cytoplasm and are differentiated in the lymph glands and spleen. These are of two types, lymphocytes and monocytes. Lymphocytes constitute 28% of WBCs. These have large round nucleus and small amount of cytoplasm. The two types of lymphocytes are B and T cells. Both B and T cells are responsible for the immune responses of the body. B cells produce antibodies to neutralize the harmful effects of foreign substances and T cells are involved in cell mediated immunity.

Monocytes (Macrophages) are phagocytic cells that are similar to mast cells and have kidney shaped nucleus. They constitute 1-3% of the total WBCs. The macrophages of the central nervous system are the 'microglia', in the sinusoids of the liver they are called 'Kupffer cells' and in the pulmonary region they are the 'alveolar macrophages'.

Platelets are also called thrombocytes that are produced from megakaryocytes (special cells in bone marrow) and lack nuclei. Blood normally contains 1, 50,000 -3, 50,000 platelets mm^{-3} of blood. They secrete substances involved in coagulation or clotting of blood. The reduction in platelet number can lead to clotting disorders that result in excessive loss of blood from the body.

7.1.3 Blood groups

Commonly two types of blood groupings are done. They are ABO and Rh which are widely used all over the world.

ABO blood grouping

Depending on the presence or absence of surface antigens on the RBCs, blood group in individual belongs to four different types namely, A, B, AB and O. The plasma of A, B and O individuals have natural antibodies (agglutinins) in them. Surface antigens are called agglutinogens. The antibodies (agglutinin) acting on agglutinogen A is called anti A and the agglutinin acting on agglutinogen B is called anti B. Agglutinogens are absent in O blood group. Agglutinogens A and B are present in AB blood group and do not contain anti A and anti B in them. Distribution of antigens and antibodies in blood groups are shown in Table 7.1. A, B and O are major allelic genes in ABO systems. All agglutinogens contain sucrose, D-galactose, N-acetyl glucosamine and 11 terminal amino acids. The attachments of the terminal amino acids are dependent on the gene products of A and B. The reaction is catalysed by glycosyl transferase.

Table 7.1 Distribution of antigens and antibodies in different blood groups

Blood group	Agglutinogens (antigens) on the RBC	Agglutinin (antibodies) in the plasma
A	A	Anti B
B	B	Anti A
AB	AB	No antibodies
O	No antigens	Anti A and Anti B

Rh factor is a protein (D antigen) present on the surface of the red blood cells in majority (80%) of humans. This protein is similar to the protein present in Rhesus monkey, hence the term Rh. Individuals who carry the antigen D on the surface of the red blood cells are Rh^+ (Rh positive) and the individuals who do not carry antigen D, are Rh^- (Rh negative). Rh factor compatibility is also checked before blood transfusion. When a pregnant women is Rh^- and the foetus is Rh^+ incompatibility (mismatch) is observed. During the first pregnancy, the Rh^- antigens of the foetus does not get exposed to the mother's blood as both their blood are separated by placenta. However, small amount of the foetal antigen becomes exposed to the mother's blood during the birth of the first child. The mother's blood starts to synthesize D antibodies. But during subsequent pregnancies the Rh antibodies from the mother (Rh^-) enters the foetal circulation and destroys the foetal RBCs. This becomes fatal to the foetus because the child suffers from anaemia and jaundice. This condition is called **erythroblastosis foetalis**. This condition can be avoided by administration of anti D antibodies (**Rhocum**) to the mother immediately after the first child birth.

7.1.4 Coagulation of blood

If you cut your finger or when you get yourself hurt, your wound bleeds for some time after which it stops to bleed. This is because the blood clots or coagulates in response to trauma. The mechanism by which excessive blood loss is prevented by the formation of clot is called blood coagulation or clotting of blood. Schematic representation of blood coagulation is shown Figure 7.4. The clotting process begins when the endothelium of the blood vessel is damaged and the connective tissue in its wall is exposed to the blood. Platelets adhere to collagen fibres in the connective tissue and release substances that form the platelet plug which provides emergency protection against blood loss. Clotting factors released from the clumped platelets or damaged cells mix with clotting factors in the plasma. The protein called prothrombin is converted to its active form called thrombin in the presence of calcium and vitamin K. Thrombin helps in the conversion of fibrinogen to fibrin threads. The threads of fibrins become interlinked into a patch that traps blood cell and seals the injured vessel until the wound is healed. After sometime fibrin fibrils contract, squeezing out a straw-

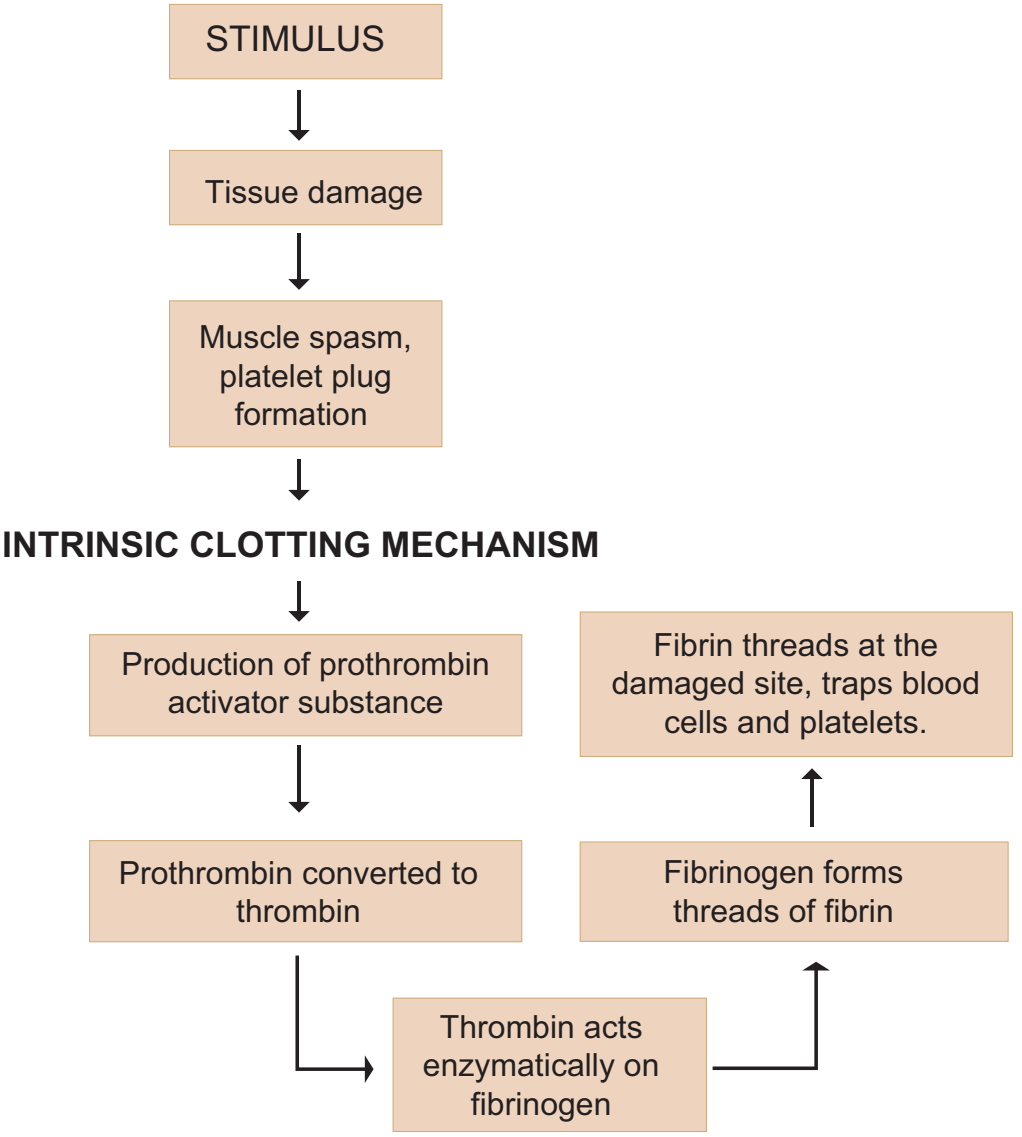


Figure 7. 4 Schematic representation of blood coagulation in an injured blood vessel

coloured fluid through a meshwork called **serum** (Plasma without fibrinogen is called serum). Heparin is an anticoagulant produced in small quantities by mast cells of connective tissue which prevents coagulation in small blood vessels.

7.1.5 Composition of lymph and its functions

About 90% of fluid that leaks from capillaries eventually seeps back into the capillaries and the remaining 10% is collected and returned to blood system by means of a series of tubules known as lymph vessels or lymphatics. The fluid inside the lymphatics is called lymph. The lymphatic system consists of a complex network of thin walled ducts (lymphatic vessels), filtering bodies (lymph nodes) and a large number of lymphocytic cell concentrations in various lymphoid organs. The lymphatic vessels have smooth walls that run parallel to the blood vessels, in the skin, along the respiratory and digestive tracts. These vessels serve as return ducts for the fluids that are continually diffusing out of the blood capillaries into the body tissues. The end of a vessel is shown in Figure 7.5. Lymph fluid must pass through the lymph nodes before it is returned to the blood. The lymph nodes that filter the fluid from the lymphatic vessels of the skin are highly concentrated in the neck, inguinal, axillaries, respiratory and digestive tracts. The lymph fluid flowing out of the lymph nodes flow into large collecting duct which finally drains into larger veins that runs beneath the collar bone, the subclavian vein and is emptied into the blood stream. The narrow passages in the lymph nodes are the sinusoids that are lined with macrophages. The lymph nodes successfully prevent the invading microorganisms from reaching the blood stream. Cells found in the lymphatics are the lymphocytes. Lymphocytes collected in the lymphatic fluid are carried via the arterial blood and are recycled back to the lymph. Fats are absorbed through lymph in the lacteals present in the villi of the intestinal wall.

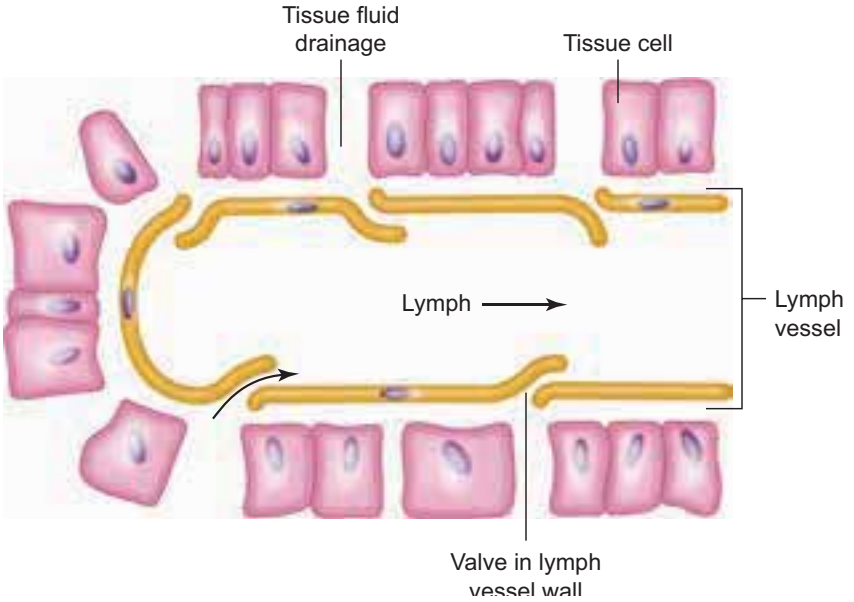


Figure 7.5 Drainage of tissue fluid into a lymph vessel

1. Why protein molecules of larger size can pass through the lymph vessel?
2. We have seen that capillary walls are not permeable to plasma proteins. Suggest where the protein comes from.
3. The disease kwashiorkor is caused by a diet which is very low in protein. The concentration of proteins in blood becomes much lower than usual. One of the symptoms of kwashiorkor is edema. Give reasons.

7.2 Structure of blood vessels

The vessels carrying the blood are of three types; they are the arteries, veins and capillaries. These vessels are hollow structures and have complex walls surrounding the lumen. The blood vessels in humans are composed of three layers, **tunica intima, tunica media** and **tunica externa**. The inner layer, tunica intima or tunica interna supports the vascular endothelium, the middle layer, tunica media is composed of smooth muscles and an extra cellular matrix which contains a protein, elastin. The contraction and relaxation of the smooth muscles results in vasoconstriction and vasodilation. The outer layer, tunica externa or tunica adventitia is composed of collagen fibres. The structure of blood vessels is illustrated in Figure 7.6.

Arteries

The blood vessels that carry blood away from the heart are called arteries. The arteries usually lie deep inside the body. The walls of the arteries are thick, non-collapsible to withstand high pressure. Valves are absent and have a narrow lumen. All arteries carry oxygenated blood, except the pulmonary artery. The largest artery, the aorta (2.5 cm in diameter and 2 mm thick) branch into smaller arteries and culminates into the tissues as feed arteries. In the tissues the arteries branches into arterioles.

As blood enters an arteriole it may have a pressure of 85 mm Hg (11.3 KPa) but as it leaves and flows into the capillary, the pressure drops to 35 mm Hg (4.7 KPa). (Note 1 mm Hg =0.13 KPa. SI unit of mm Hg is KiloPascal (KPa)). Arterioles are small, narrow, and thin walled which are connected to the capillaries. A small sphincter lies at the junction between the arterioles and capillaries to regulate the blood supply. Arteries do not always branch into arterioles, they can also form anastomoses.

DO YOU KNOW?

What are anastomoses? These are connections of one blood vessel (arteries) with another blood vessel. They provide alternate route of blood flow if the original blood vessel is blocked. For e.g., Arteries in the joints contain numerous anastomoses. This allows blood to flow freely even if one of the arteries closes during bending of the joints.

Capillaries

Capillary beds are made up of fine networks of capillaries. The capillaries are thin walled and consist of single layer of

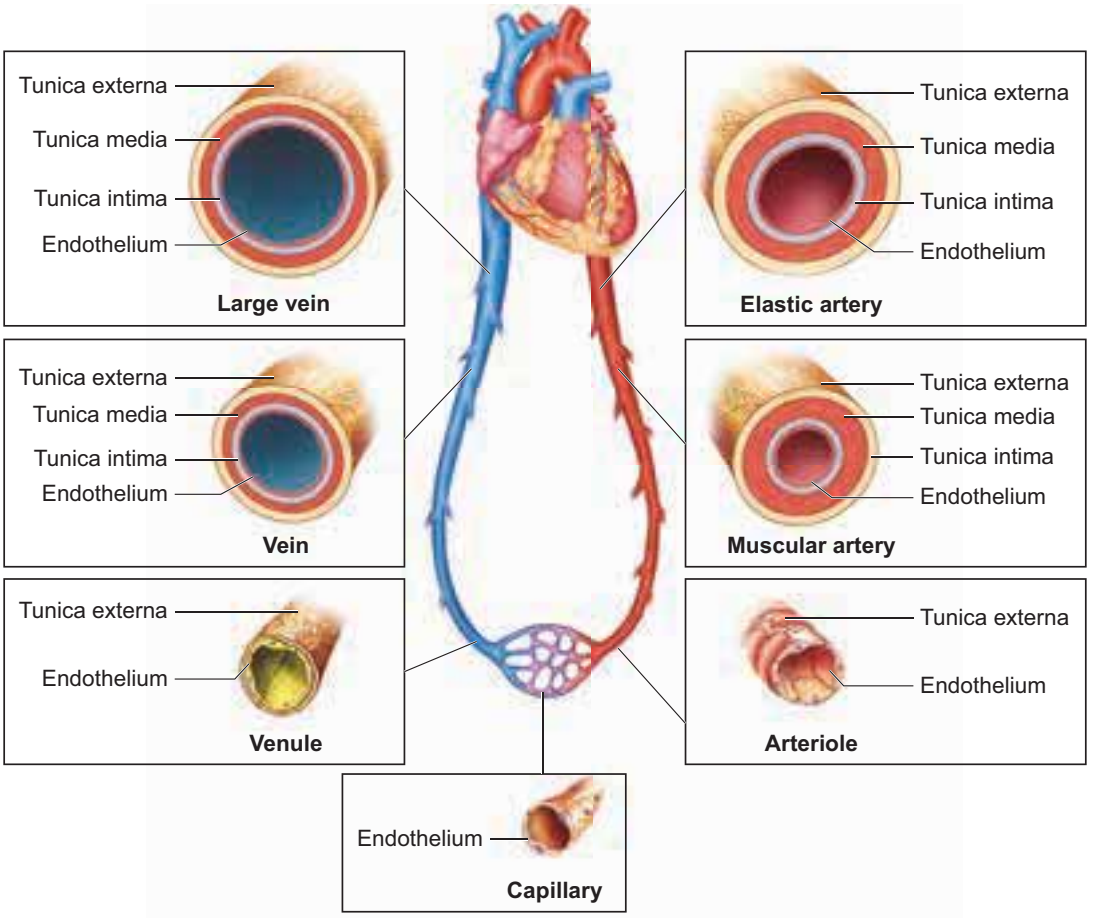


Figure 7.6 Structure of Blood vessels

squamous epithelium. Tunica media and elastin fibres are absent. The capillary beds are the site for exchange of materials between blood and tissues. The walls of the capillaries are guarded by semilunar valves. The blood volume in the capillaries is high but the flow of blood is slow. Mixed blood (oxygenated and deoxygenated) is present in the capillaries. The capillary bed may be flooded with blood or may be completely bypassed depending on the body conditions in a particular organ.

Why there are no blood capillaries in the cornea of the eye and cartilage? How are these regions supplied with the required nutrients?

Veins

Veins have thinner walls and a larger lumen and hence can be easily stretched. They carry deoxygenated blood except, the pulmonary vein. The blood pressure is low and the lumen has a wide wall which is collapsible. Tunica media is thinner in veins than in arteries. Unidirectional flow of blood in veins is due to the presence of semilunar valves that prevents backflow of blood. Blood samples are usually taken from the veins rather than artery because of low pressure in the veins.

7.2.1 Coronary blood vessels

Blood vessels that supply blood to the cardiac muscles with all nutrients and removes wastes are the coronary arteries

Suggest why arteries close to the heart have more elastic fibers in their walls than arteries further away from the heart?

When exercising vigorously, blood is rerouted from the digestive organ (food or no food) to the capillary beds of the skeletal muscles where it is needed immediately. This rerouting explains why vigorous exercise after a meal can cause indigestion or abdominal cramps.

The Law of Laplace is used to understand the structure and function of blood vessels and the heart. Laplace law states that the tension in the walls of the blood vessel is proportional to the blood pressure and vessel radius. Blood vessels such as aorta that is subjected to high pressures have thicker walls than the arterioles that are subjected to low pressures.

and veins. Heart muscle is supplied by two arteries namely right and left coronary arteries. These arteries are the first branch of the aorta. Arteries usually surround the heart in the manner of a crown, hence called coronary artery (L. *Corona* - crown).

Right ventricle and posterior portion of left ventricle are supplied by the right coronary artery. Anterior and lateral part of the left ventricle is supplied by the left coronary arteries.

7.3 Circulatory pathways

6LD8DJ

There are two types of circulatory systems, open and closed circulatory systems. **Open circulatory system has** haemolymph as the circulating fluid and is pumped by the heart, which flows through blood vessels into the sinuses. Sinuses are referred as haemocoel. Open circulatory system is seen in Arthropods and most Molluscs. In **closed circulatory system** blood is pumped by the heart and flows through blood vessels. Closed circulating system is seen in Annelids, Cephalopods and Vertebrates.

All vertebrates have muscular chambered heart. Fishes have two chambered heart. The heart in fishes consists of sinus venosus, an atrium, one ventricle and bulbus arteriosus or conus arteriosus. Single circulation is seen in fishes. Amphibians have two auricles and one ventricle and no inter ventricular septum whereas reptiles except crocodiles have two auricles and one ventricle and an incomplete inter ventricular septum. Thus mixing of oxygenated and deoxygenated blood takes place in the ventricles. This type of circulation is called incomplete double circulation. The left atrium receives oxygenated blood and the right atrium receives deoxygenated blood. Pulmonary and systemic circuits are seen in Amphibians and Reptiles. The Crocodiles, Birds and Mammals have two auricles or atrial chambers and two ventricles, the auricles and ventricles are separated by inter auricular septum and inter ventricular septum. Hence there is

complete separation of oxygenated blood from the deoxygenated blood. Pulmonary and systemic circuits are evident. This type of circulation is called complete double circulation.

7.4 Human circulatory system

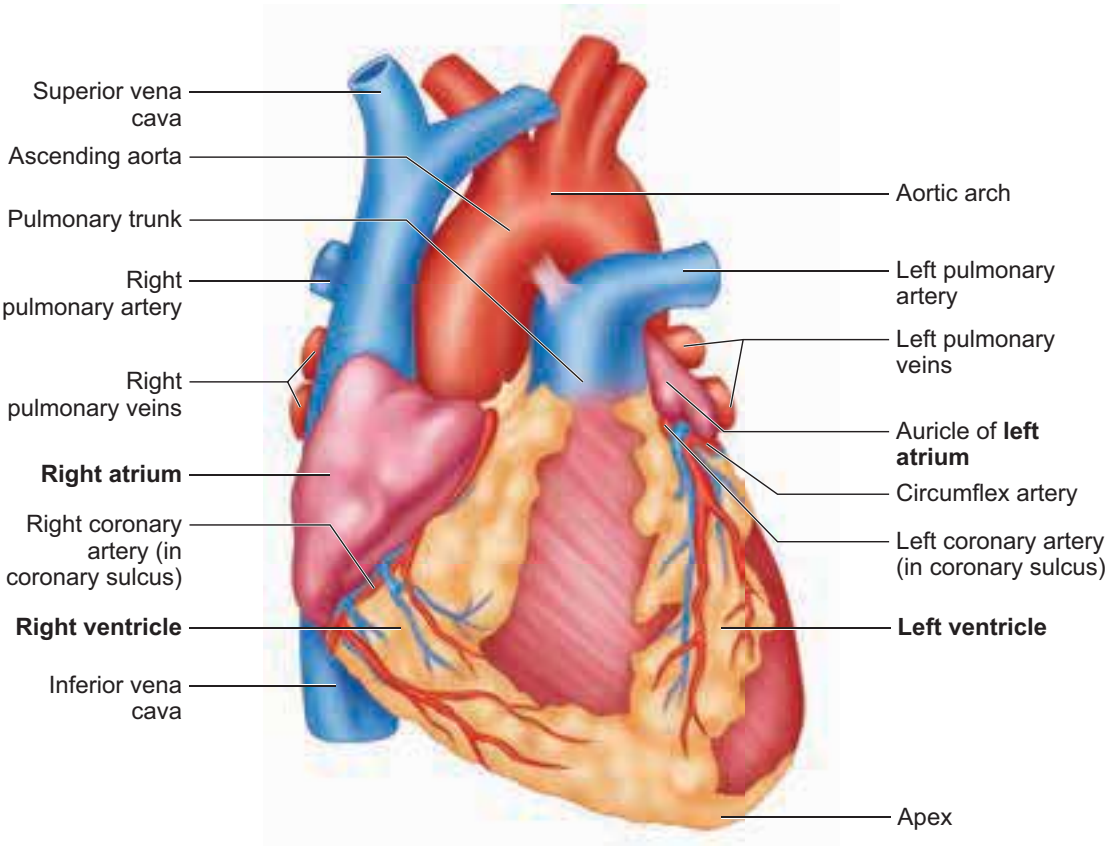
The structure of the heart was described by Raymond de viessens, in 1706. Human heart is made of special type of muscle called the cardiac muscle. It is situated in the thoracic cavity and its apex portion is slightly tilted towards left. It weighs about 300g in an adult. The size of our heart is roughly equal to a closed fist. The structure of heart and the L.S of heart are shown in Figure 7.7 (a) and (b). Heart is divided into four chambers, upper two small auricles or atrium and lower two large ventricles. The walls of the ventricles are thicker than the auricles due to the presence of papillary muscles. The heart wall is made up of three layers, the outer epicardium, middle myocardium and inner endocardium. The space present between the membranes is called pericardial space and is filled with pericardial fluid.

The two auricles are separated by inter auricular septum and the two ventricles are separated by inter ventricular septum The separation of chambers avoids mixing of oxygenated and deoxygenated blood. The auricle communicates with the ventricle through an opening called auriculo ventricular aperture which is guarded by the auriculo ventricular valves. The opening between the right atrium and the right ventricle is guarded by the **tricuspid valve** (three flaps or cusps), whereas a **bicuspid** (two flaps or cusps) or **mitral valve** guards the opening between the left atrium and left ventricle. The valves of the heart allows the blood to flow only in one direction, i.e., from the atria to the ventricles and from the ventricles to the pulmonary artery or the aorta. These valves prevent backward flow of blood.

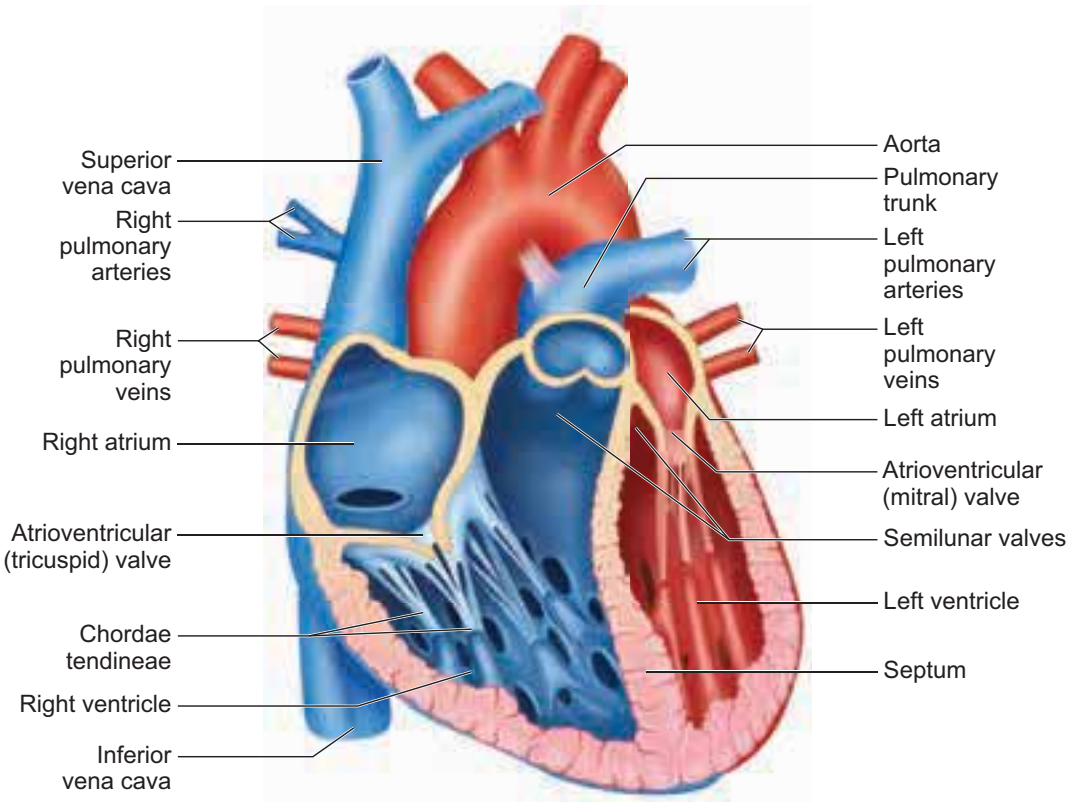
The opening of right and left ventricles into the pulmonary artery and aorta are guarded by aortic and pulmonary valves and are called **semilunar valves**. Each semilunar valve is made of three half-moon shaped cusps. The myocardium of the ventricle is thrown into irregular muscular ridges called **trabeculae corneae**. The trabeculae corneae are modified into **chordae tendinae**. The opening and closing of the semilunar valves are achieved by the chordae tendinae. The chordae tendinae are attached to the lower end of the heart by papillary muscles. Heart receives deoxygenated blood from various parts of the body through the inferior venacava and superior venacava which open into the right auricle. Oxygenated blood from lungs is drained into the left auricle through four pulmonary veins.

7.4.1 Origin and conduction of heart beat

The heart in human is myogenic (cardiomyocytes can produce spontaneous rhythmic depolarisation that initiates contractions). The sequence of electrical conduction of heart is shown in Figure 7.8. The cardiac cells with fastest rhythm are called the Pacemaker cells, since they determine the contraction rate of the entire heart. These cells are located in the right sinuatrial (SA) node/ Pacemaker. On the left side of the right atrium is a node called auriculo



(a)



(b)

Figure 7.7 (a) - Structure of the heart **(b)** L.S of Heart

ventricular node (AV node). Two special cardiac muscle fibres originate from the auriculo ventricular node and are called the bundle of His which runs down into the interventricular septum and the fibres spread into the ventricles. These fibres are called the Purkinje fibres.

Pacemaker cells produce excitation through depolarisation of their cell membrane. Early depolarisation is slow and takes place by sodium influx and reduction in potassium efflux. Minimum potential is required to activate voltage gated calcium (Ca+) channels that causes rapid depolarisation which results in action potential. The pace maker cells repolarise slowly via K^+ efflux.

HEART BEAT- Rhythmic contraction and expansion of heart is called heart beat. The contraction of the heart is called **systole** and the relaxation of the heart is called **diastole**. The heart normally beats 70-72 times per min in a human adult. During each cardiac cycle two sounds

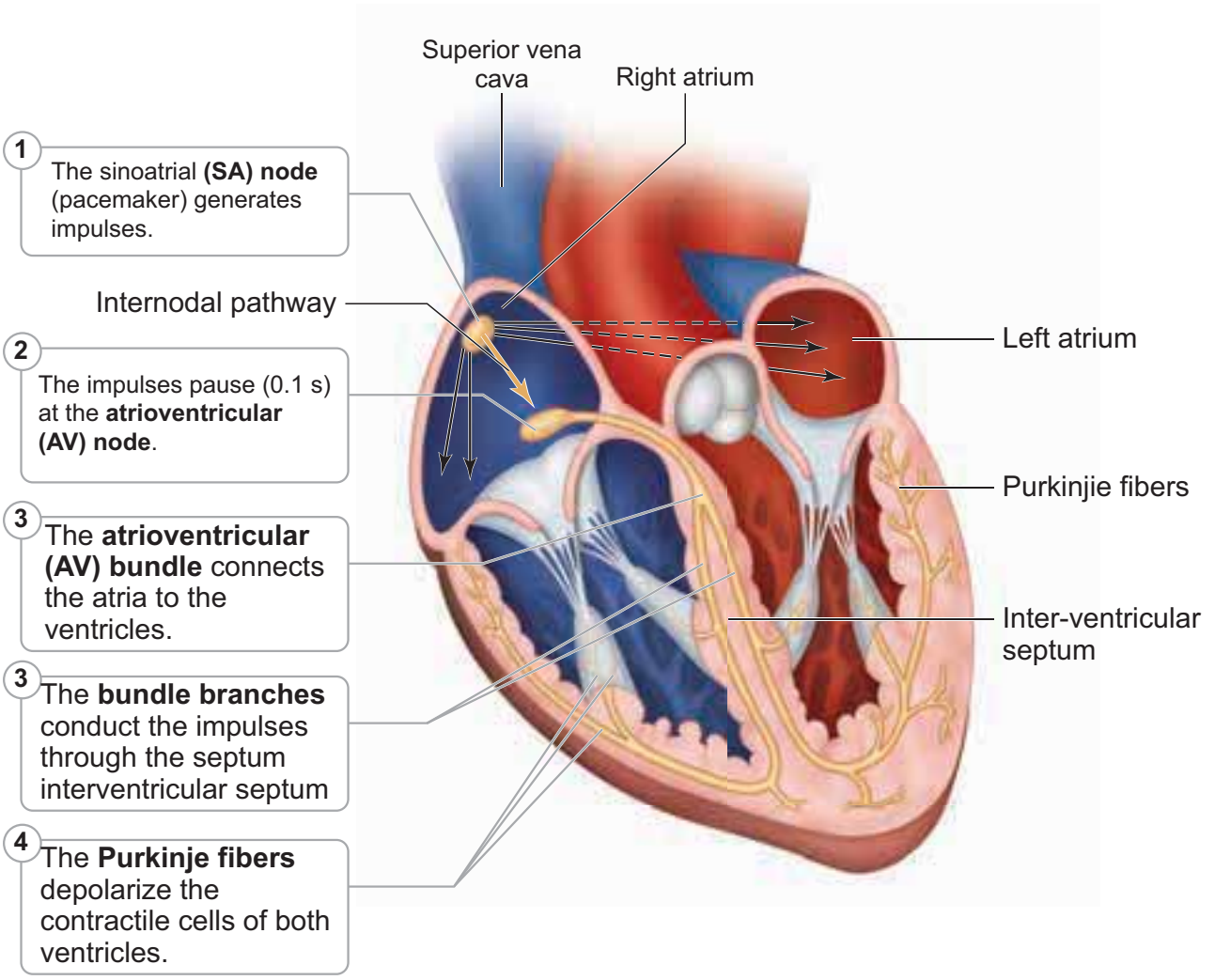


Figure 7.8 The sequence of electrical conduction of heart.

are produced that can be heard through a **stethoscope**. The first heart sound (lub) is associated with the closure of the tricuspid and bicuspid valves whereas second heart sound (dub) is associated with the closure of the semilunar valves. These sounds are of clinical diagnostic significance. An increased heart rate is called tachycardia and decreased heart rate is called bradycardia.

7.4.2 Cardiac Cycle

The events that occur at the beginning of heart beat and lasts until the beginning of next beat is called cardiac cycle. It lasts for 0.8 seconds. The series of events that takes place in a cardiac cycle.

PHASE 1: Ventricular diastole- The pressure in the auricles increases than that of the ventricular pressure. AV valves are open while the semi lunar valves are closed. Blood flows from the auricles into the ventricles passively.

PHASE 2: Atrial systole - The atria contracts while the ventricles are still relaxed. The contraction of the auricles pushes maximum volume of blood to the ventricles until they reach the end diastolic volume (EDV). EDV is related to the length of the cardiac muscle fibre. More the muscle is stretched, greater the EDV and the stroke volume.

PHASE 3: Ventricular systole (isovolumetric contraction) - The ventricular contraction forces the AV valves to close and increases the pressure inside the ventricles. The blood is then pumped from the ventricles into the aorta without change in the size of the muscle fibre length and ventricular chamber volume (isovolumetric contraction).

PHASE 4: Ventricular systole (ventricular ejection) - Increased ventricular pressure forces the semilunar valves to open and blood is ejected out of the ventricles without backflow of blood. This point is the end of systolic volume (ESV).

PHASE 5: (Ventricular diastole) -The ventricles begins to relax, pressure in the arteries exceeds ventricular pressure, resulting in the closure of the semilunar valves. The heart returns to phase 1 of the cardiac cycle.

7.4.3 Cardiac output

The amount of blood pumped out by each ventricle per minute is called cardiac output(CO). It is a product of heart rate (HR) and stroke volume (SV). Heart rate or pulse is the number of beats per minute. Pulse pressure = systolic pressure – diastolic pressure. Stroke volume (SV) is the volume of blood pumped out by one ventricle with each beat. SV depends on ventricular contraction. CO = HR X SV. SV represents the difference between EDV (amount of blood that collects in a ventricle during diastole) and ESV (volume of blood remaining in the ventricle after contraction). SV = EDV - ESV. According to Frank – Starling law of the heart, the critical factor controlling SV is the degree to which the cardiac muscle cells are stretched just before they contract. The most important factor stretching cardiac muscle is the amount of blood returning to the heart and distending its ventricles, venous return. During vigorous exercise,

SV may double as a result of venous return. Heart's pumping action normally maintains a balance between cardiac output and venous return. Because the heart is a double pump, each side can fail independently of the other. If the left side of the heart fails, it results in pulmonary congestion and if the right side fails, it results in peripheral congestion. Frank – Starling effect protects the heart from abnormal increase in blood volume.

When blood volume drops down abruptly, what happens to the stroke volume? State whether it increases or decreases?

Blood Pressure

Blood pressure is the pressure exerted on the surface of blood vessels by the blood. This pressure circulates the blood through arteries, veins and capillaries. There are two types of pressure, the systolic pressure and the diastolic pressure. Systolic pressure is the pressure in the arteries as the chambers of the heart contracts. Diastolic pressure is the pressure in the arteries when the heart chambers relax. Blood pressure is measured using a sphygmomanometer (BP apparatus). It is expressed as systolic pressure / diastolic pressure. Normal blood pressure in man is about 120/80mm Hg. Mean arterial pressure is a function of cardiac output and resistance in the arterioles. The primary reflex pathway for homeostatic control of mean arterial pressure is the baroreceptor reflex. The baroreceptor reflex functions every morning when you get out of bed. When you are lying flat the gravitational force is evenly distributed. When you stand up, gravity causes blood to pool in the lower extremities. The decrease in blood pressure upon standing is known as orthostatic hypotension. Orthostatic reflex normally triggers baroreceptor reflex. This results in increased cardiac output and increased peripheral resistance which together increase the mean arterial pressure.

7. 4. 4 Electrocardiogram (ECG)

An electrocardiogram (ECG) records the electrical activity of the heart over a period of time using electrodes placed on the skin, arms, legs and chest. It records the changes in electrical potential across the heart during one cardiac cycle. The special flap of muscle which initiates the heart beat is called as sinu-auricular node or SA node in the right atrium. It spreads as a wave of contraction in the heart. The waves of the ECG are due to depolarization and not due to contraction of the heart. This wave of depolarisation occurs before the beginning of contraction of the cardiac muscle. A normal ECG shows 3 waves designated as P wave, QRS complex and T wave as shown in Figure 7.9 and the stages of the ECG graph are shown in Figure 7.10.

P Wave (atrial depolarisation)

It is a small upward wave and indicates the depolarisation of the atria. This is the time taken for the excitation to spread through atria from SA node. Contraction of both atria lasts for around 0.8-1.0 sec.

PQ Interval (AV node delay)

It is the onset of P wave to the onset of QRS complex. This is from the start of depolarisation of the atria to the beginning of ventricular depolarisation. It is the time

taken for the impulse to travel from the atria to the ventricles (0.12-0.21sec). It is the measure of AV conduction time.

QRS Complex (ventricular depolarisation)

No separate wave for atrial depolarisation in the ECG is visible. Atrial depolarisation occurs simultaneously with the ventricular depolarisation. The normal QRS complex lasts for 0.06-0.09 sec. QRS complex is shorter than the P wave, because depolarisation spreads through the Purkinjie fibres. Prolonged QRS wave indicates delayed conduction through the ventricle, often caused due to ventricular hypertrophy or due to a block in the branches of the bundle of His.

ST Segment

It lies between the QRS complex and T wave. It is the time during which all regions of the ventricles are completely depolarised and reflects the long plateau phase before repolarisation. In the heart muscle, the prolonged depolarisation is due to retardation of K+ efflux and is responsible for the plateau. The ST segment lasts for 0.09 sec.

T wave (ventricular depolarisation)

It represents ventricular depolarisation. The duration of the T wave is longer than QRS complex because repolarisation takes place simultaneously throughout the ventricular depolarisation.

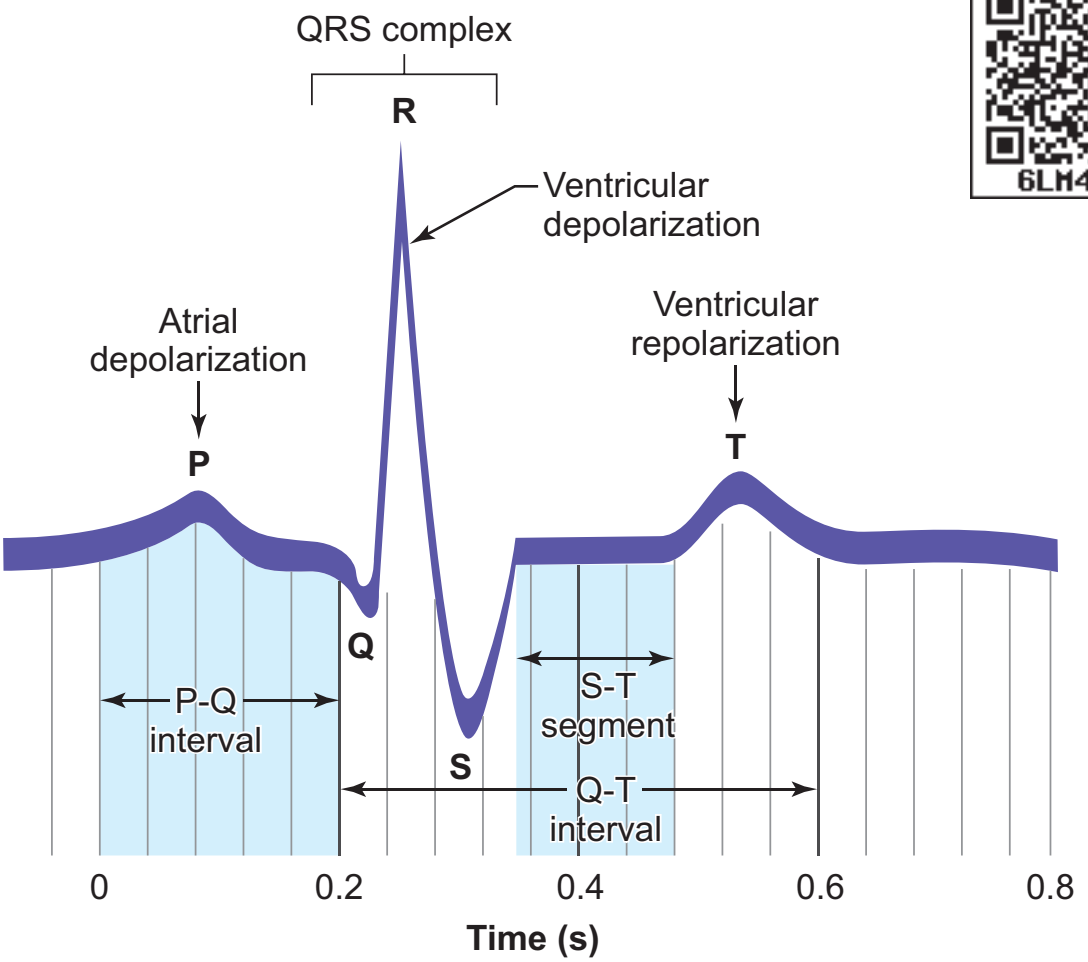


Figure 7.9 Graph of a normal ECG

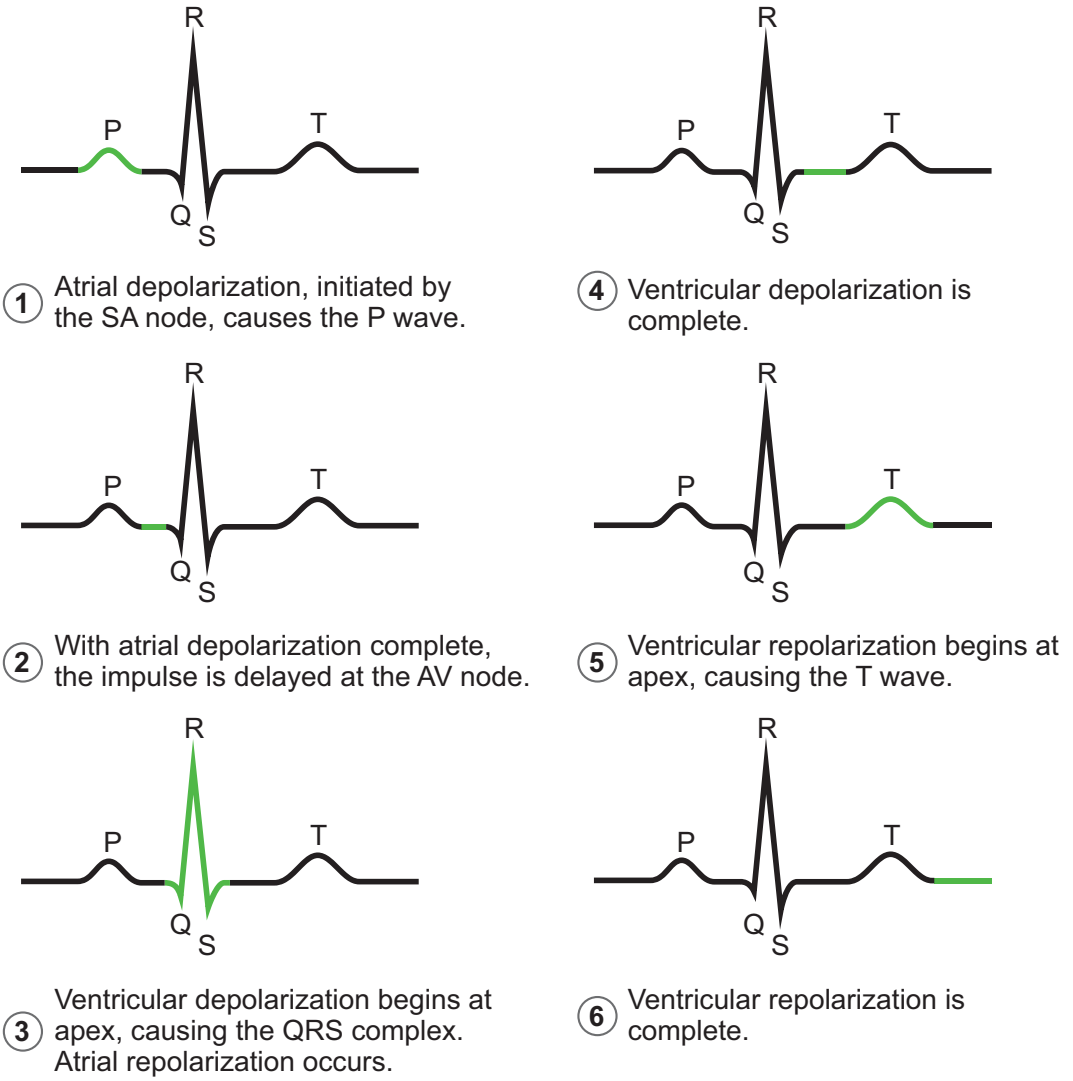


Figure 7.10 Stages of ECG graph

7.5. Double circulation

Circulation of the blood was first described by William Harvey (1628). There are two types of blood circulation in vertebrates, single circulation and double circulation which is shown in Figure 7.11 (a and b) and 7.12.

The blood circulates twice through the heart first on the right side then on the left side to complete one cardiac cycle. The complete double blood circulation is more prominent in mammals because of the complete partition of all the chambers (Auricles and ventricles) in the heart.

In systemic circulation, the oxygenated blood entering the aorta from the left ventricle is carried by a network of arteries, arterioles and capillaries to the tissues. The deoxygenated blood from the tissue is collected by venules, veins and vena cava and emptied into the right atrium. In pulmonary circulation, the blood from heart (right ventricle) is taken to the lungs by pulmonary artery and the oxygenated blood from the lungs is emptied into the left auricle by the pulmonary vein.

Completely separated circuits have an important advantage. Different pressures are maintained in the pulmonary

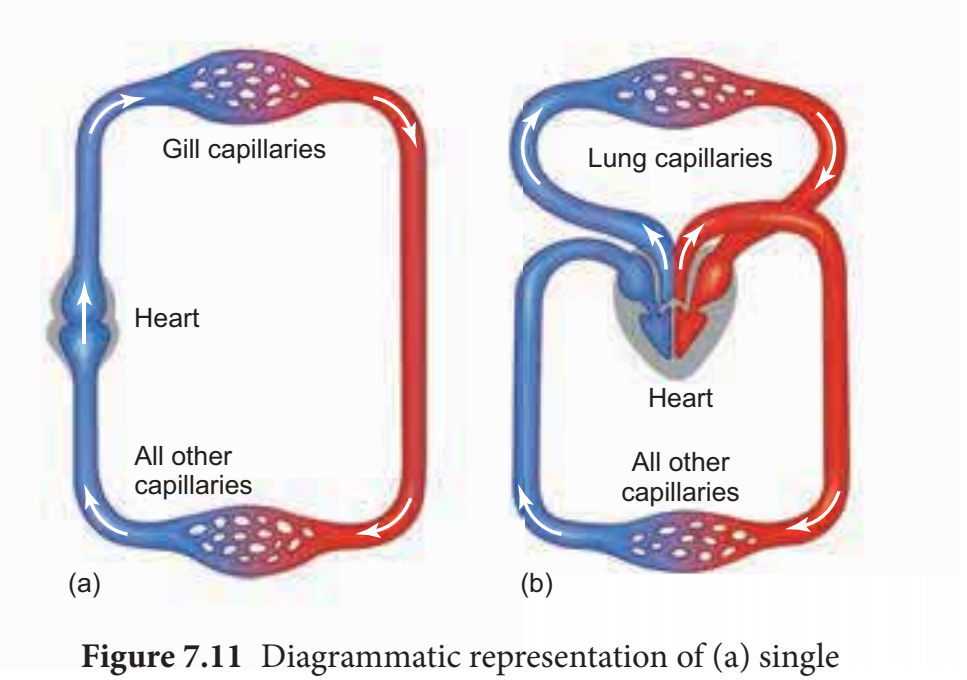


Figure 7.11 Diagrammatic representation of (a) single circulation (b) double circulation

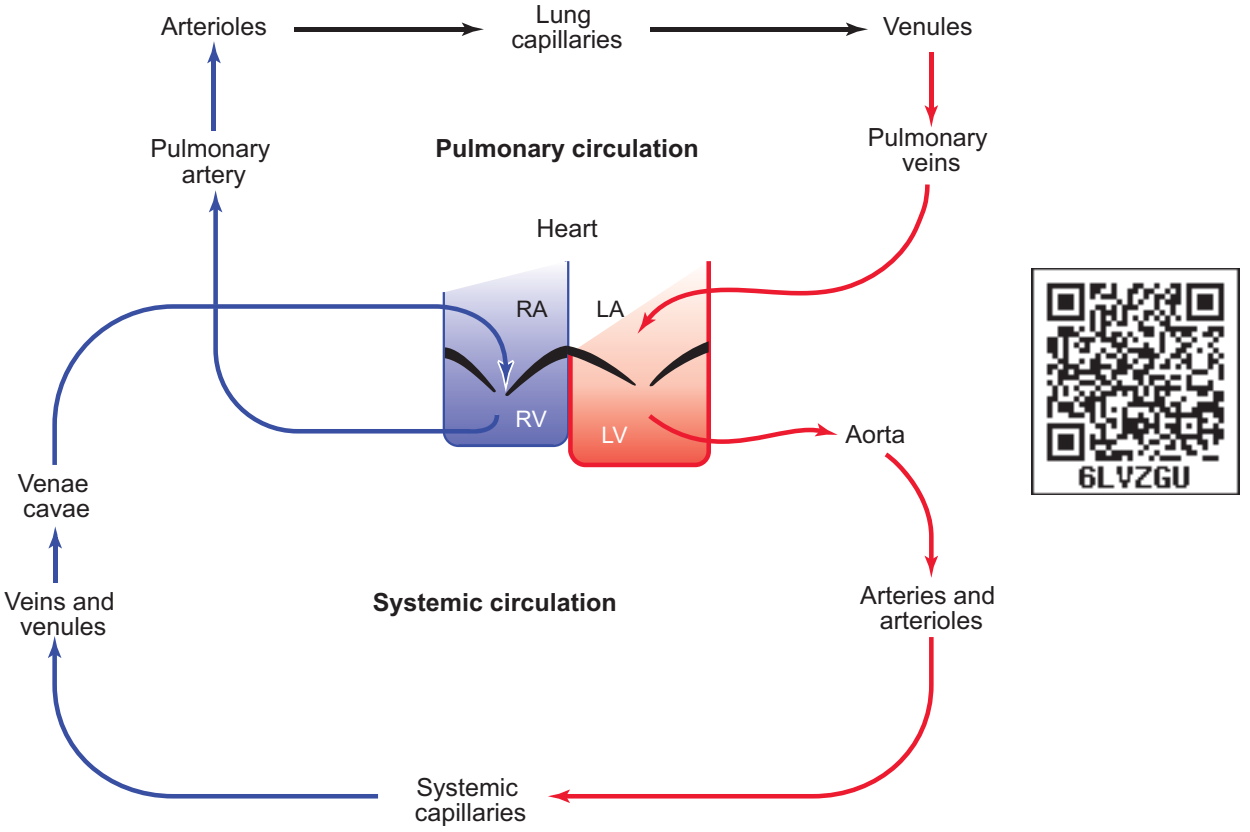


Figure 7.12 Diagrammatic representation of the Double circulation

and systemic circulation. Why is this advantageous? In the lungs the capillaries must be very thin to allow gas exchange, but if the blood flows through these thin capillaries under high pressure the fluid can leak through or ruptures the capillary walls and can accumulate in the tissues. This increases the diffusion distance and reduces the efficiency of the gas exchange. In contrast high pressure

is required to force blood through the long systemic circuits. Hence the arteries close to the heart have increased pressure than the arteries away from the heart. Completely separated circuits (pulmonary and systemic) allow these two different demands to be met with.

7. 6 Regulation of cardiac activity

The type of heart in human is myogenic because the heart beat originates from the muscles of the heart. The nervous and endocrine systems work together with paracrine signals (metabolic activity) to influence the diameter of the arterioles and alter the blood flow. The neuronal control is achieved through autonomic nervous system (sympathetic and parasympathetic). Sympathetic neurons release nor-epinephrine and adrenal medulla releases epinephrine. The two hormones bind to β – adrenergic receptors and increase the heart rate. The parasympathetic neurons secrete acetylcholine that binds to muscarinic receptors and decreases the heart beat. Vasopressin and angiotensin II, involved in the regulation of the kidneys, results in vasoconstriction while natriuretic peptide promotes vasodilation. Vagus nerve is a parasympathetic nerve that supplies the atrium especially the SA and the AV nodes.

7.7 Disorders of the circulatory system

Hypertension is the most common circulatory disease. The normal blood pressure in man is 120/80 mmHg. In cases when the diastolic pressure exceeds 90 mm Hg and the systolic pressure exceeds 150 mm Hg persistently, the condition is called hypertension. Uncontrolled hypertension may damage the heart, brain and kidneys.

Coronary heart disease occurs when the arteries are lined by **atheroma**. The build-up of atheroma contains cholesterol, fibres, dead muscle and platelets and is termed Atherosclerosis. The cholesterol rich atheroma forms plaques in the inner lining of the arteries making them less elastic and reduces the blood flow. Plaque grows within the artery and tends to form blood clots, forming coronary thrombus. Thrombus in a coronary artery results in heart attack.

Stroke

Stroke is a condition when the blood vessels in the brain bursts, (Brain haemorrhage) or when there is a block in the artery that supplies the brain, (atherosclerosis) or thrombus. The part of the brain tissue that is supplied by this damaged artery dies due to lack of oxygen (cerebral infarction).

Angina pectoris (ischemic pain in the heart muscles) is experienced during early stages of coronary heart disease. Atheroma may partially block the coronary artery and reduce the blood supply to the heart. As a result, there is tightness or choking with difficulty in breathing. This leads to **angina** or chest pain. Usually it lasts for a short duration of time.

Myocardial infarction (Heart failure)

The prime defect in heart failure is a decrease in cardiac muscle contractility. The Frank- Starling curve shifts downwards and towards the right such that for a given EDV, a failing heart pumps out a smaller stroke volume than a normal healthy heart.

When the blood supply to the heart muscle or myocardium is remarkably reduced it leads to death of the muscle fibres. This condition is called heart attack or myocardial infarction. The blood clot or thrombosis blocks the blood supply to the heart and weakens the muscle fibres. It is also called **Ischemic** heart disease due to lack of oxygen supply to the heart muscles. If this persists it leads to chest pain or angina. Prolonged angina leads to death of the heart muscle resulting in heart failure.

Rheumatoid Heart Disease

Rheumatic fever is an autoimmune disease which occurs 2-4 weeks after throat infection usually a streptococcal infection. The antibodies developed to combat the infection cause damage to the heart. Effects include fibrous nodules on the mitral valve, fibrosis of the connective tissue and accumulation of fluid in the pericardial cavity.

7.8 Diagnosis and Treatment

Angiogram

Angiogram is a procedure that uses a special dye and X-ray to see how blood flows through the coronary arteries of the heart and it can be used to detect abnormality in the blood vessels through out the body.

Angioplasty

Angioplasty is the stretching of an artery that is narrowed due to atherosclerosis. The risk involved in this procedure is minimal. During an angioplasty a small long balloon catheter is threaded through the blocked artery. A deflated balloon is attached to the catheter and the balloon is inflated to widen the arterial wall. Then the tube and the balloon are removed. A small metal scaffold called stent is left in place. This scaffolding keeps the blood vessel open and allows free flow of blood. Slow releasing stents are now available that can release chemicals to prevent further block of the artery.

Varicose veins The veins are so dilated that the valves prevent back flow of blood. The veins lose their elasticity and become congested. Common sites are legs, rectal-anal regions (haemorrhoids), the oesophagus and the spermatic cord.

Embolism is the obstruction of the blood vessel by abnormal mass of materials such as fragment of the blood clot, bone fragment or an air bubble. Embolus may lodge in the lungs, coronary artery or liver and leads to death.

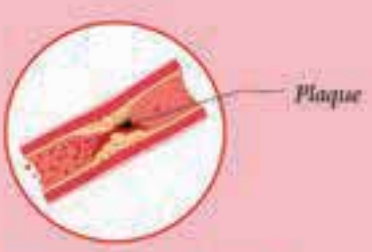
Aneurysm The weakened regions of the wall of the artery or veins bulges to form a balloon like sac. Unruptured aneurysm may exert pressure on the adjacent tissues or may burst causing massive haemorrhage.

Bypass Surgery

When the arteries that bring blood to the heart muscles (coronary artery) are blocked by plaque (accumulation of fat, cholesterol and other substances) the person is advised to undergo Bypass surgery. After the surgery the blood flow to coronary artery is increased and the person is relieved from chest pain. This is a major surgery where damaged blood vessel is replaced by the healthy one taken from

Heart Diseases

Heart disease includes any disorder of the heart, 50% of all heart attacks in Indians occur under 50 years of age and 25% of all heart attacks in Indians occur under 40 years of age.

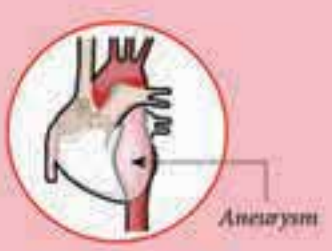


Coronary heart disease

Blocked or clogged arteries limit blood flow to the heart and starving it of oxygen and nutrients.

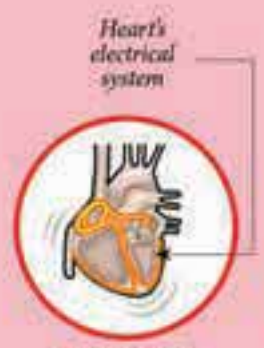
Vascular disease

Heart disease is often related to diseases of the circulatory system, including arteries, veins and lymph vessels, or blood disorders.



Aorta disease

A portion of the aortic wall weakens and balloons out, forming an aneurysm.



Arrhythmia

The heart beats irregularly.

Pericarditis

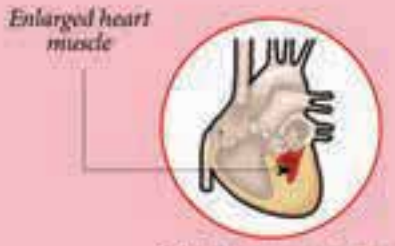
An inflammation of one or more layers of the pericardium, a thin membrane that lines the heart.

Heart failure

The heart cannot pump as powerfuly as it needs to, in order to supply the body with oxygen and nutrients, causing the heart muscles to overwork and weaken.

Heart valve disease

One of more of the hearts' valves - which control blood flow into and out of the heart - does not work.



Cardiomyopathy

An enlarged or abnormally stiff or thick heart, causing the heart to pump weaker than normal and sometimes leading to heart failure or arrhythmia.

different part of the body. Mostly it is taken from legs. During this surgery patients blood system is connected with a pump oxygenator (heart lung machine). After the completion of the surgery the blood vessel is connected to normal the circulation and the blood flows freely.

Heart Tnansplantation

A heart transplant is a surgical transplantation procedure which is done to replace a diseased or a damaged heart. This procedure is performed on a patient with end stage heart failure or severe coronary artery disease, when other medical ailments or surgical treatments have failed. The most common procedure is to take a functioning heart from a brain dead person (organ donor) and is transplanted in a person with a damaged heart. After the heart transplant the average life span of the person increases.

Cardio pulmonary resuscitation (CPR)

In 1956, James Elam and Peter Safar were the first to use mouth to mouth resuscitation. CPR is a life saving procedure that is done at the time of emergency conditions such as when a person's breath or heart beat has stopped abruptly in case of drowning, electric shock or heart attack. CPR includes rescue of breath, which is achieved by mouth to mouth breathing, to deliver oxygen to the victim's lungs by external chest compressions which helps to circulate blood to the vital organs. CPR must be performed within 4 to 6 minutes after cessation of breath to prevent brain damage or death. Along with CPR, defibrillation is also done. Defibrillation means a brief electric shock is given to the heart to recover the function of the heart.

Each year over several million people worldwide die of heart disease, than from other conditions. For some patients heart transplant is the only hope. Raju was 62 years old when muscles of both the ventricles had deteriorated. He was lucky enough because biomedical engineers were able develop a pumping device called 'total artificial heart'. Raju's heart was completely removed and an artificial heart was put in place. He was able to go home within a few weeks. This artificial heart would have kept him in alive until suitable real heart was available for transplant.

First heart transplantation was performed in the year 1959. Human heart transplant was performed by Prof. Christian Bernard in South Africa in the year 1967, December 3 at Groote Schuur Hospital, Cape Town. Dr Anangipalli Venugopal was the first to perform heart transplant at AIIMS, India on August 3, 1994.

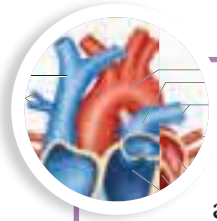
Activity

Ramu was 45 years old when he went to a doctor to check his blood pressure. His pressure was around 158/98mmHg. The doctor advised him to measure his blood pressure at home for two weeks. He came to the doctor saying his average blood pressure was around 160/100mmHg. Doctor concludes that Ramu has high blood pressure or hypertension. If not controlled, hypertension can lead to heart failure, stroke and kidney failure. He returned to the doctor after two months after taking the drug, ACH inhibitor. This chemical blocks the production of angiotensin II, a powerful vasoconstrictor, so his blood pressure returned back to normal.

1. Why are people with high blood pressure at greater risk for having a hemorrhagic stroke?
2. Without medication Ramu's blood pressure was around 160/100mmHg after two weeks. Why this pressure was referred to as hypertension by the doctor.
3. Blocking the action of vasoconstrictor lowers the blood pressure? Give reasons.
4. What is the role of ACH inhibitor in reducing blood pressure?
5. What conditions one might expect if the blood pressure is not controlled?

ICT Corner

The vital flow



Let's explore the **circulatory system** and learn the the 'Phases of Cardiac Cycle'.

Step – 1

Type the following URL in the browser. 'Circulatory System page will open. Select 'Phases of Cardiac Cycle' from the grid.

Step – 2

From the given Phases of Cardiac Cycle, Play one after another using 'Play' button and observe the valve movements and blood circulation in the heart.

Step – 3

The last animation shows the entire functions and flows of the Cardiac cycle. Use Play, Forward and Backward buttons and observe the nuances of Heart function.

Step – 4

Use the links below the Phases to get more details about the locations, size, chambers and pericardium structures.

Step 1

Step 2

Step 3

Step 4

Phases of the Cardiac Cycle's URL:

https://www.getbodysmart.com/circulatory-system

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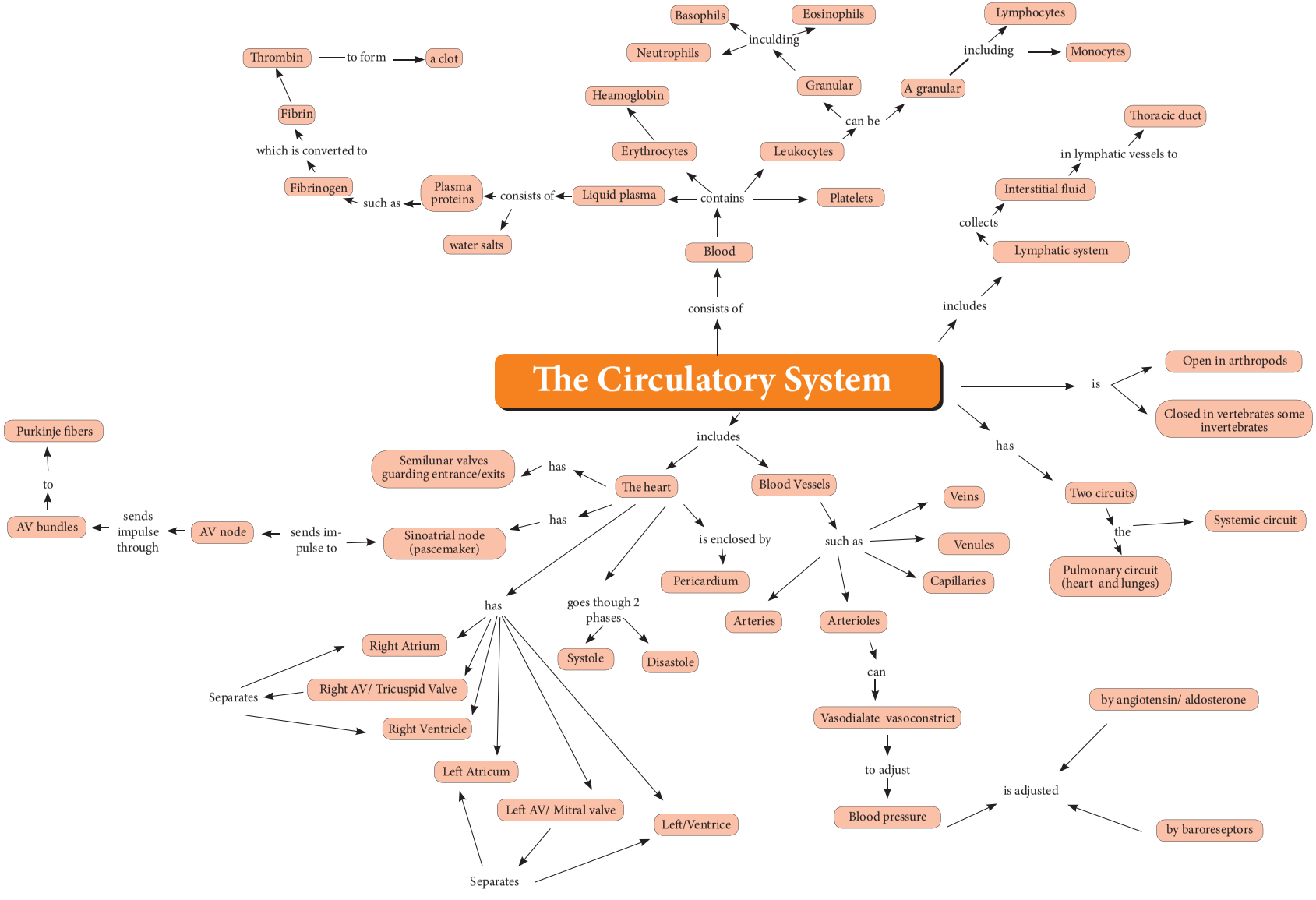
* Pictures are indicative only

Concept Map



Summary

Vertebrates circulate blood in their body, to transport essential substances to the cells and to carry waste substances from them. Blood is carried away from the heart, passes through tissues in capillaries and is returned to the heart in veins. Blood pressure drops gradually as it passes along this system. Arteries have thick, elastic walls which allow them to withstand high blood pressure. Arterioles are small arteries that help to reduce blood pressure and control the amount of blood flow to different tissues. Capillaries are only just wide enough to allow the passage of red blood cells, and have very thin wall to allow efficient and rapid transfer of materials between blood and cells. Veins have thinner walls than arteries and possess valves that allow blood to flow back to the heart even at low pressure.

Blood consist of plasma and formed elements. Blood plasma leaks from capillaries to form tissue fluid. This is collected into lymphatics as lymph, and returned to the blood in the subclavian veins. Tissue fluid and lymph are almost identical in composition. They contain fewer plasma protein molecules than blood plasma as these proteins are too large to pass through the pores in the capillary walls. The formed elements of blood constitute RBC, WBC and Platelets.

The mammalian heart has four chambers, right and left artia and right and left ventricles. The separation of chambers in the heart results in complete double circulation. The cardiac cycle is a continuous process but can be considered in five stages. Beating of the heart is initiated by the sinoatrial node (SAN) or pacemaker which has its own myogenic rhythm. Blood pressure is the force exerted by blood on the walls of blood vessels, and it is responsible for moving blood through the vessels.

Cardiovascular disease accounts for more deaths each year in the India. Cardiovascular conditions include systemic hypertension, atherosclerosis, coronary artery disease, angina pectoris, myocardial infarction and stroke. Cardiovascular diagnostic techniques and treatments include cardiac angiography, balloon angioplasty, and coronary artery bypass. The circulatory system contributes to homeostasis by transporting O_2, CO_2, wastes, electrolytes, and hormones from one part of the body to another.

Glossary

Blood vessels serve as a passage way through which the blood is directed and distributed from the heart to all parts of the body and subsequently returned to the heart.

Pulmonary circulation – consists of closed loop of vessels carrying blood between the heart and lungs.

Systemic circulation – is a circuit of vessels carrying blood between the heart and other parts of body systems.

Cardio pulmonary resuscitation (CPR) – Serves as a life saving measure until appropriate therapy can restore the heart to normal function.

Aorta – A single large artery carrying blood away from the left ventricle.

Bicuspid valve – also called mitral valve. Left Auricular ventricular valve with two flaps that is present between the left auricle and left ventricle.

Tricuspid valve – right auricular valve with three flaps that is present between the right auricle and right ventricle.

Chordate tendineae – these are chords that extend from the edge of each flap and attach to the papillary muscles that prevent the AV valves from being forced to open due to high ventricular pressure.

Papillary muscles – small nipple shaped muscles protrude from the inner surface of the ventricular walls. Papilla means 'nipple'.

Sinoatrial node (SA node), – a small, specialised region in the right atrial wall near the opening of the superior vena cava

Atrioventricular node (AV node), – a small bundle of specialized cardiac muscle cells locted at the base of the right atrium near the septum, just above the junction of the atria and ventricles.

Bundle of His – (atrioventicular bundle), a tract of specialized cells that originates at the AV node and enters the interventricular septum

Purkinje fibres – small terminal fibres that extend from the bundle of His and spread throughout the ventricular myocardium

Stroke volume (SV) – The amount of blood pumped out of each ventricle with each contraction, SV = EDV-ESV

Isovolumetric ventricular contraction – Isovolumetric means constant volume and length. During ventricular contraction, when all valves are closed, no blood can enter or leave the ventricle during this time. Because no blood leaves or enters the ventricles the ventricular chamber has a constant volume and the muscle fibres stay at a constant length.

End systolic volume (ESV) – The ventricles do not empty completely during ejection, only half of the blood within the ventricle at the end of diastole is pumped out during subsequent systole. The amount of blood left in the ventricle at the end of systole when ejection is complete is called ESV.

End diastolic volume (EDV) – The volume of blood in the ventricle at the end of diastole is known as the end diastolic volume.

Lub sound – is associated with the closure of the AV valves.

Dub sound – is associated with the closure of the semilunar valves.

Chordae tendinae – tendon like cords which are connected to the tip of the cuspid valves

Diastole – Relaxation of heart chambers

Endocardium – Inner cardiac muscle

Epicardium – outer cardiac muscle

Inter ventricular septum – Partition between right and left ventricle

Interatrial septum – Partition between right and left atria

Left atrioventricular valve – Bicuspid valve or Mitral valve

Evaluation

1. What is the function of lymph?
   a. Transport of O_2 into brain
   b. Transport of CO_2 into lungs
   c. Bring interstitial fluid in blood
   d. Bring RBC and WBC in lymph node
2. Which one of the following plasma proteins is involved in the coagulation of blood?
   a. Globulin b. Fibrinogen
   c. Albumin d. Serum amylase
3. Which of the following WBCs are found in more numbers?
   a. Eosinophil b. Neutrophil
   c. Basophil d. Monocyte
4. Which of the following is not involved in blood clotting?
   a. Fibrin b. Calcium
   c. Platelets d. Bilirubin
5. Lymph is colourless because
   a. WBC are absent

b. WBC are present

c. Heamoglobin is absent

d. RBC are absent

6. Blood group is due to the presence or absence of surface

a. Antigens on the surface of WBC

b. Antibodies on the surface of RBC

c. Antigens of the surface of RBC

d. Antibodies on the surface of WBC

7. A person having both antigen A and antigen B on the surface of RBCs belongs to blood group

a. A b. B c. AB d. O

8. Erythroblastosis foetalis is due to the destruction of

a. Foetal RBCs

b. Foetus suffers from atherosclerosis

c. Foetal WBCs

d. Foetus suffers from mianmata

9. Dub sound of heart is caused by

a. Closure of atrio-ventricular valves

b. Opening of semi-lunar valves

c. Closure of semi-lunar values

d. Opening of atrio-ventricular valves.

10. Why is the velocity of blood flow the lowest in the capillaries?

a. The systemic capillaries are supplied by the left ventricle, which has a lower cardiac output than the right ventricle.

b. Capillaries are far from the heart, and blood flow slows as distance from the heart increases.

c. The total surface area of the capillaries is larger than the total surface area of the arterioles.

d. The capillary walls are not thin enough to allow oxygen to exchange with the cells.

e. The diastolic blood pressure is too low to deliver blood to the capillaries at a high flow rate.

11. An unconscious patient is rushed into the emergency room and needs a fast blood transfusion. Because there is no time to check her medical history or determine her blood type, which type of blood should you as her doctor, give her?

a. A^- b. AB c. O^+ d. O^-

12. Which of these functions could or could not be carried out by a red blood cell? Briefly justify your answer.

a. Protein synthesis

b. Cell division

c. Lipid synthesis

d. Active transport

13. At the venous end of the capillary bed, the osmotic pressure is

a. Greater than the hydrostatic pressure

b. Result in net outflow of fluids

c. Results in net absorption of fluids

d. No change occurs.

14. A patient's chart reveals that he has a cardiac output of 7500mL per minute and a stroke volume of 50 mL. What is his pulse rate (in beats / min)

a. 50 b. 100 c. 150 d. 400

15. At any given time there is more blood in the venous system than that of the arterial system. Which of the following features of the veins allows this?

a. relative lack of smooth muscles

b. presence of valves

c. proximity of the veins to lymphatic's

d. thin endothelial lining

16. Distinguish between arteries and veins
17. Distinguish between open and closed circulation
18. Distinguish between mitral valve and semi lunar valve
19. Right ventricular wall is thinner than the left ventricular wall. Why?
20. What might be the effect on a person whose diet has less iron content?
21. Describe the mechanism by which the human heart beat is initiated and controlled.
22. What is lymph? Write its function.
23. What are the heart sounds? When and how are these sounds produced?
24. Select the correct biological term.

    Lymphocytes, red cells, leucocytes, plasma, erythrocytes, white cells, haemoglobin, phagocyte, platelets, blood clot.

    a. Disc shaped cells which are concave on both sides
    b. Most of these have a large, bilobed nucleus
    c. Enable red cells to transport blood
    d. The liquid part of the blood
    e. Most of them move and change shape like an amoeba.
    f. Consists of water and important dissolved substances.
    g. Destroyed in the liver and spleen after circulating in the blood for four months.
    h. The substances which gives red cells their colour.
    i. Another name for red blood cells.
    j. Blood that has been changed to a jelly.
    k. A word that means cell eater.
    l. Cells without nucleus.
    m. White cells made in the lymphatic tissue.
    n. Blocks wound and prevent excessive bleeding.
    o. Fragment of cells which are made in the bone marrow.
    p. Another name for white blood cells.
    q. Slowly releases oxygen to blood cells.
    r. Their function is to help blood clot in wounds.

25. Select the correct biological term.

    Cardiac muscle, atria, tricuspid systole, auricles, arteries, diastole, ventricles, bicuspid valve, pulmonary artery, cardiac cycle, semi lunar valve, veins, pulmonary vein, capillaries, vena cava, aorta.

    a. The main artery of the blood.
    b. Valves between the left atrium and ventricle.
    c. Technical name for relaxation of the heart.
    d. Another name for atria.
    e. The main vein.
    f. Vessels which carry blood away from the heart.
    g. Two names for the upper chambers of the heart.
    h. Thick walled chambers of the heart.
    i. Carries blood from the heart to the lungs.
    j. Takes about 0.8 sec to complete.
    k. Valves situated at the point where blood flows out of the heart.

l. Vessels which carry blood towards the heart.

m. Carries blood from the lungs to the heart.

n. The two lower chambers of the heart.

o. Prevent blood from re entering the ventricles after entering the aorta.

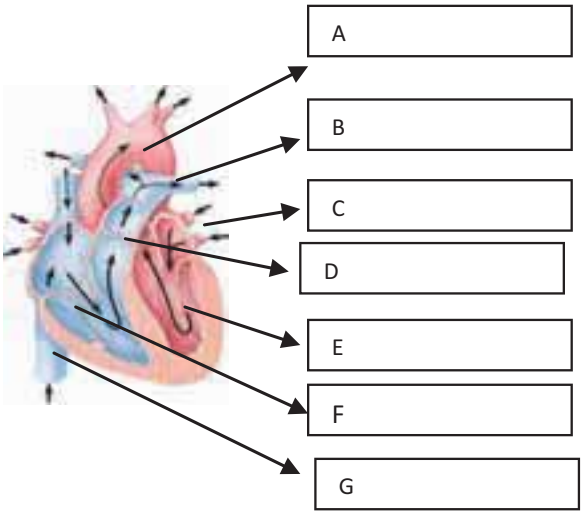
p. Technical name for one heart beat.

q. Valves between right atrium and ventricles.

r. Technical name for contraction of the heart.

s. Very narrow blood vessels.

26. Name and Label the given diagrams to show A, B, C, D, E, F, and G



References

1. Christopher D. Moyes and Patricia M. Schulte (2016), Principles of animal physiology 2nd edition Pearson publications.
2. Mary Jones, Richard Fosbery, Jennifer Gregory and Dennis Taylor, Cambridge International AS and A level Biology Course book 4th edition, Cambridge University Press.
3. Elaine N. Marieb and Katja Hoehn (2011), Anatomy and Physiology 4th edition Pearson publications.

Web links

1. Online and Interactive Resources
   a. www.fi.edu/learn/heart/blood/blood.html for information about blood.
   b. www. abpischools.org.uk it includes a glossary, questions and animations.
   c. www.youtube.com/watch?v+kcWNjt77uHc for description of cardiac cycle. www. brookerbiology.com

QUESTIONS FOR NATIONAL LEVEL ENTRANCE EXAMS FOR HIGHER STUDIES

COMPILED FROM PMT, AIPMT, NEET, AIIMS AND EXAMS OF SIMILAR KIND

Chapter 1. LIVING WORLD

1. The smallest taxon among the following is …….(PMT-94)

a. class b. order

c. species d. genus

2. Taxonomically a species is ……. (PMT-94)

a. A group of evolutionary related population

b. A fundamental unit in the phylogeny of organisms

c. Classical evolutionary taxonomy

d. A community taken into considerationa. an evolutionary base

3. Species is …….

a. not related to evolution

b. specific class of evolution

c. specific unit of evolution

d. fertile specific unit in the evolutionary history of a race

4. Two words comprising the binomial nomenclature are ……. (DPMT-96)

a. Family & genus

b. order & family

c. genus & species

d. species & variety

5. A group of plants or animals with similar traits of any rank is kept under …. (PMT-96)

a. species b. genus

c. order **d. taxon**

6. Which of the following is the correct sequence in the increasing order of complexity ? (PMT-97)

a. molecules, tissues, community, population

b.cell, tissues, community, population

c. tissues, organisms, population, community

d.molecules, tissues, community, cells

7. New systematic and the concept of life was given by (BHU-98)

a. Huxley b. Odom

c. Elton d. Linnaeus

8. Two organisms of same class but different families will be kept under the same (CET-98)

a. genera b. species

c. order d. family

9. Which of the following will form a new species ? (PMT-98)

a. inter breeding

b. variations

c. differential reproduction

d. none of the above

10. A community includes ……. (CET-98)

a. a group of same genera

b. a group of same population

c. a group of individuals from same species

d. different populations interacting with each other

11. Binomial nomenclature was given by ……. (BHU-97)

a. Huxley b. Ray

c. Darwin **d. Linnaeus**

12. In classification the category below the level of family is ……. (CET-98)

a. class b. species

c. phylum **d. genus**

13. Taxon is ……. (CET-2000)

a. species

b. unit of classification

c. highest rank in classification

d. group of closely related

14. One of the following includes most closely linked organisms (PMT-2001)

a. species b. genus

c. family d. class

15. Which of the following taxons cover a greater number of organisms ? (PMT-2001)

a. order b. family

c. genus **d. phylum**

16. Inbreeding is possible between two members of ……. (AMU-2005)

a. order b. family

c. genus **d. species**

17. Which of these is correct order of hierarchy? (WARDHA-2002)

a. kingdom, division, phylum genus & species

b. phylum, division, genus & class

c. kingdom, genus, class, phylum & division

d. phylum, kingdom, genus, species &class

18. Which is not a unit of taxonomic category? (BVP-2002)

a. series **b. glumaceae**

c. class d. phylum

19. Which is the first step of taxonomy ? (MGIMS-2002)

a. nomenclature b. classification

c. identification d. hierarchical arrangement

20. The five kingdom classification was given by ……. (BYP-2002)

a. Whittaker b. Linnaeus

c. Copeland d. Haeckel

21. Taxon includes ……. (PMT-2002)

a. Genus and species

b. kingdom and division

c. all ranks of hierarchy

d. none of the above

22. Binomial nomenclature refers to ……. (CET-2000)

a. Two names of a species

b. one specific and one local name of a species

c. two words for the name of a species

d. two life cycles ofa. organism

23. Carl Linnaeus is famous for ……. (GGSPU-2002)

a. coining the term 'systematics'

b. introducing binomial nomenclature

c. giving all natural system of classification

d. all of these

24. True species are …….

a. interbreeding b. sharing the same niche

c. feeding on the same food

d. reproductively isolated

25. The smallest unit of classification is ……. (GGSPU-2002)

a. species b. sub-species

c. class d. genus

26. Who coined the term 'taxonomy' ? (BVP-2003)

a. Candolle b. Waksman

c. Leuwenhoek d. Louis Pasteur

27. Basic unit of classification of organisms is ……. (CET-2003)

a. species b. population

c. class d. family

28. The unit of classification containing concrete biological entities is ……. (WARDHA-2003)

a. taxon b. species

c. category d. order

29. Species are considereda. …….

a. real basic units of classification

b. the lowest units of classification

c. artificial concept of human mind which cannot be defined in absolute terms

d. real units of classification devised by taxonomists

30. The living organisms can be unexceptionally distinguished from the non-living things on the basis of their ability for ……..

a. interaction with the environment and progressive evolution

b. reproduction

c. growth and movement

d. responsiveness to touch

31. Taxonomic category arrange in descending order ……. (MH-01)

a. key b. hierarchy

c. taxon **d. taxonomic category**

32. In which of the animal dimorphic nucleus is found? (PMT 2002).

a. Amoeba proteus

b. Trypanosoma gambiense

c. Plasmodium vivax

d. Paramecium caudatum

33. When a fresh-water protozoan possessing a contractile vacuole, is placed in a glass containing marine water, the vacuole will. (PMT 2004)

a. increase in number b. disappear

c. increase in size **d. decrease in size**

34. Which form of reproduction is correctly matched? (AIIMS 2007)

a. Euglena transvers binary fission

b.Paramecium longitudinal binary fission

c. Amoeba multiple fission

d. Plasmodium binary fission

35. The presence of two types of nuclei, a macronucleus and a micronucleus, is characteristic of protozoans are grouped under the class. (BHU 1994, 1999)

a. sporozoa b. flagellate

c. sarcodina **d. ciliata**

36. Which class of protozoa is totally parasitic? (BHU 1994)

a. sporozoa b. mastigophora

c. ciliate d. sarcodina

37. Reproduction in paramecium is controlled by (BHU 1999).

a. flagella b. cell wall

c. micronucleus d. macronucleus

38. In the life cycle of plasmodium exflagellation occurs in (BHU 2007)

a. sporozoties **b. microgametes**

c. macrogametes d. signet ring

39. Excretion in Amoeba occurs through (DPMT 1997)

a. lobopodia b. plasma membrane

c. uroid portion **d. contractile vacuole**

40. Method of dispersal in Amoeba is (DPMT 1995)

a. locomotion **b. encystment**

c. sporulation d. binary fission

41. Mode of feeding in free living protozoans is (DPMT 2007).

a. holozoic b. saprozoic

c. both (a) and (b) d. none of these

42. Infection of Entamoeba is caused (UP- CPMT 1996, 1999).

a. by kissing

b. by wearing clothes of patient

c. by contaminated food

d. none of these

43. Choose the correct statement

a. All reptiles have a three chambered heart.

b. All Pisces have gills covered bya. operculum

c. All mammals are viviparous

d. All cyclostomes do not posses jaws and paired fin

44. Which of the following characteristics is mainly responsible for diversification of insects on land?

a. Segmentation b. Bilateral symmetry

c. Exoskeleton d.Eyes.

45. The primitive prokaryotes responsible for the production of biogas from the ruminant animals Include the (2016)

a. Thermoacidophiles

b. methanogens

c. Eubacteria

d. Halophiles.

46. Methanogens belong to (2016)

a. Dino flagellates

b. Slime moulds

c. Eubacteria

d. Archaebacteria

Chapter 2 KINGDOM ANIMALIA

1. Classification of sponges is primarily based on the (JCECE-2003)

a. body organization b. body plan

c. skeleton d. canal system

2. Symmetry is cnidaria is (AMU-2009)

a. radial b. bilateral

c. pentamerous d. spherical

3. Cavity of coelenterates is called (BHU-2008)

a. coelenteron b. coelom

c. cavity d. none of these

4. Sea anemone bolongs to phylum (BCECE-2005)

a. protozoa b. porifera

c. coelenterata d. echinodermata

5. Medusa is the Reproductive organs of (BHU-2008)

a. Hydra **b. Aurelia**

c. obelia d. sea anemone

6. The excretory cells, that are found in platyhelminthes. (J & K CET- 2007)

a. Protonephridia **b. flame cells**

c. Solenocytes d. All of these

7. In which of the following organisms, self fertilization is seen. (CCET-2007)

a. fish b. Round worm

c. Earthworm **d. Liver fluke**

8. Nephridia of Earthworms are performing same function as. (J & K CET-2003)

a. gills of prawn

b. flame cells of planaria

c. trachea of insects

d. nematoblasts of Hydra

9. Phylum of *Taenia solium* is (BCECE-2004)

a. Aschelminthes b. Annelids

c. platylyelminthes d. mollusca

10. Ascaris is found in (RPMT-2004)

a. body cavity b. lymph nodes

c. tissue **d. alimentary canal**

11. Which of the following animals has a true coelom ? (J & K CET-2007)

a. Ascaris **b. pheretima**

c. sycon d. Taenia solium

12. Metameric segmentation is the main feature of

a. Annelida

b. Echinodermata

c. Arthropoda

d. Coelenterata

13. Body cavity lined by mesoderm is called (J & T CET-2005)

a. coelenteron b. pseudocoel

c. coelom d. blastocoel

14. Which of the following have the highest number of species in nature? (AIPMT-2011)

a. Insects b. Birds

c. Angiosperms d. Fungi

15. Which of the following is a crustacean ? (Guj-CET-2011)

a. prawn b. snail

c. sea anemone d. Hydra

16. The respiratory pigment present in cockroach is (OJEE-2010)

a. Haemoglobin

b. Haemocyanin

c. oxyhaemoglobin

d. None of these

17. Book lungs are respiratory organs in (AMU-2008)

a. Insects b**. Aarachnids**

c. Molluscans d. Echinoderms

18. The exerctory organ in cockroach is (Kerala-CEE-2007)

a. malplghian corpuscle

b. Malpighian tubules

c. green gland

d. Metanephridia

19. Exoskeleton of which phylum consists of chitinous cuticle ? (J & K CET-2007)

a. Annelida

b. porifera

c. Arthropoda

d. Echinodermata

20. In cockroach, vision is due to (PMET-2005)

a. one compound eye

b. two compound eyes

c. two simple eyes

d. two compund and two simple eyes.

21. Which of the following respires through gills? (J & K CET-2005)

a. whale b. Turtle

c. frog d**. Prawns**

22. Animals which active at night are called. (J & K CET-2004)

a. diurnal b**. nocturnal**

c. parasites d. nocto-diurnal

23. Salient features of Arthropoda is (RPMT-2003)

a. aquatic and free living

b. chitinous exoskeleton and jointed appendages

c. radulla

d. none of those

24. The second largest number of species containing phylum in the animal kingdom is (J & K CET-2008)

a. Annelida b. Arthropoda

c. Mollusca d. Chordata

25. Mollusca is (JCECE-2006)

a. Triploblastic, acoelomate

b**. Triploblastic, coelomate**

c. Diploblastic, acoelomate

d. Diploblastic, coelomate

26. Tube feet are the locomotory organs of

a. platyhelminthes

b. Echinodermata

c. Mollusca

d. Arthropoda

27. Given below are four matchings of a animal and its kind of respiratory organ (PMT 2003)

(A) Silver fish - Trachea
(B) Scorpion - Book lung
(C) Sea squirt - Pharyngeal gills
(D) Dolphin - Skin

The correct matchings are

a. A and B b**. A,B and C**

c. B and D d. C and D

28. Which one of the following is a matching pair of ananimal and a certain phenomenon it exhibits? (PMT 2003)

a) Pheretima - Sexual dimorphism

b) Rana - Complete metamorphosis

c) Chameleon - Mimicry

d) Taenia - Polymorphism

29. Two common characters found in centipede, cockroach, and crab and (PMT 2006)

a. book lungs and antennae

b. compound eyes and anal cerci

c. joint legs and chitinous exoskeleton

d. green gland and tracheae

30. Which one of the following groups of animals is bilaterally symmetrical and triploblastic? (PMT 2009)

a. aschelminthes (round worms)

b. ctenophores

c. sponges

d. coelenterates (cnidarians)

31. Which one feature is common to leech, cockroach and scorpion? (AIIMS 2004)

a. nephridia

b. ventral nerve cord

c. cephalization

d. antennae

32. Whch one of the following features is common in silverfish, scorpion, dragonfly and prawn?

a. Three pairs of legs and segmented body

b. Chitinous cuticle and two pairs of antennae

c. Jointed appendages and chitinous exoskeleton

d. Cephalothorax and trachea

33. Peripatus is known as a connecting link, because it has the characters of both (BHU 1993).

a. Fishes & amphibians

b. Reptiles & birds

c. Aves & fishes

d. Arthropoda & annelids

34. Osphradium of *Pila globosa* is (BHU 1994, 2000, 2007)

a. thermoreceptor

b. Pheretima

c.chemoreceptor

d. tangoreceptor

35. Green glands present in some arthropods help in (BHU 1998, 2007)

a. respiration **b. excretion**

c . digestion d. none of these

36. Squid, cuttle fish and Octopus belongs to class of (BHU 1998, 2001)

a. decapoda b. scaphopoda

c. cephalopoda d. apods

39. The canal system is a characteristic feature of (BHU 1999, 2002)

a. **sponges** b. echinoderms

c . helminthes d. coelenterates

40. Malpighian tubules are (BHU 2006)

a**. excretory organs of insects**

b. excretory organs of frog

c. respiratory organs of insects

d. endocrine glands of insects

41. Caterpiller and maggot are (BHU 2007

a. larvae b. nymphs

c. adults d. pupa

42. Excretory organ of platyhelminths is (BHU 2008)

a. gills **b. flame cells**

c. nephridia d. trachea

43. Water vascular system is a characteristic of (BHU 2008)

a. ctenophore

b. annelid

c. echinodermata

d.arthropoda

44. Tube feet are the characteristic structures of (DPMT 1993, 2008)

a. jellyfish **b. starfish**

c. cuttlefish d. crayfish

45. Horomone, which helps in metamorphosis in insects is (DPMT 1996)

a.pheromone **b. ecdysone**

c. thyroxine d.all of these

46. The muscles associated with the heart of insects are (DPMT 1996, 2006)

a. alary b. striped

c. radial d.pericardial

47. Which of the following organisms is pseudocoelomate? (DPMT 2001, 2006)

a. hookworm b. liver fluke

c. jelly fish d. leech

48. Which of the following is not reported to have any fresh water forms? (DPMT 2003)

a. Mollusca b. Sponges

c. Coelenterates **d. echinoderms**

49. Pseudocoelom is not found in (DPMT 2004)

a. *Ascaris* b. *Ancylostoma*

c. *Fasciola* d. none of these

50. Animals devoid of respiratory, excretory and circulatory organs are belongs to phylum (DPMT 2004)

a. echinodermata

b. platyhelminthes

c. porifera d. mollusca

51. Cilia of gills of bivalve molluscs help in (DPMT 2005)

a. protection **b. respiration**

c. excretion d. feeding

52. All flat worms differ from all round worms in having(DPMT 2009)

a. triploblastc body

b. solid mesoderm

c. bilateral symmetry

d. metamorphosis in the life istory

53. Parthenogenesis can be seen in (UP-CPMT 1995)

a. frog **b. honey bee**

c. moth d. all of these

54. The endocrine gland of insects, wich secretes they juvenile hormone, is (UP-CPMT 1995)

a. corpora allata

b. corpora albicans

c. corpora myecaena

d. all of these

55. Malpighian tubules are (UP-CPMT 1996, 2008)

a. excretory organs of insects

b. respiratory organs of insects

c. excretory organs of frog

d. endocrine glands of insects

56. In mollusca, eye is present over a stalk called (UP-CPMT 2000, 2007)

a. osphradium b. ostracum

c. ommatophore d. operculum

57. Which of the following symmetries is found in adult sea anemone? (UP - CPMT 2004)

a. radial b. biradial

c. bilateral d. spherical

58. Feeding in sponges takes place through (UP-CPMT 2005)

a**. choanocytes** b. nurse cells

c. ostia d.osculum

59. Osphradium is meant for (UP-CPMT 2005)

a. excretion b. nutrition

c. selection and rejection of food

d. grindingof food

60. Excretory product of spider is (UP-CPMT 2007)

a. uric acid b. ammonia

c**. guanine** d. none of these

61. Which of the following is not the charcter of *Taenia solium* (UP-CPMT 2007)

a. polysis b. proglottid

c. metamerism d. strobila

62. Daphnia is commonly known as (UP-CPMT 2007)

a. clam shrimp b. fairy shrimp

c. water fleas d. tadpole shrimp

63. Wuchereria is found in (UP-CPMT 2007)

a**. lymph nodes** b. lungs

c. eye d. gonds

64. "Turbellarians" are free living (UP-CPMT 2008)

a**. flatworms** b. trematodes

c. nematodes d. cesrtodes

65. Polyp phase is absent in (UP-CPMT 2008)

a. Physalia b. Obselia

c. Hydra d**. Aurelia**

66. Animals having pseudocoelomate and triploblastic nature are present in phyla (UP-CPMT 2008).

a. annelida

b. arthropoda

c. aschelminthes

d. platyhelminthes

67. Primitive nervous system is formed in (UP-CPMT 2009)

a. sponge

b**. cnidaria (coelenterate)**

c. echinodermata

d. annelida

68. Tissues are absent in the body of (UP-CPMT 2009)

a**. sponge**

b. annelida

c. platyhelminthes

d. arthropoda

69. Linmulus belongs to class

a. onychophora b. insect

c**. merostomata** d. crustacea

70. Ambulacral system is mainly useful for

a. locomotion **b. feeding**

c. circulation d. defence

71. Which of the following isa. excretory organ in mollusca?

a. Keber's organ b. nephridia

c. Malphingan organ d. Flame cells

72. Mouth parts of housefly are

a. Piercing and sucking type

b. Biting and sucking type

c. Sponging and sucking type

d. biting and chewing type

73. Anus is absent in

a. Periplaneta b. Unio

c. Fasciola d. Pheretima

74. Asymmetry in gastropoda is due to

a. twistig **b. torsion**

c. coiling c. none of these

75. The pigment haemocyanin is found in

a. mollusca b.chordate

c. echinodermata d.annelida

76. The development of adult characteristics in a moulting insect is promoted by

a. pheromone b. thyroxine

c. juvenile hormone **d. ecdysone**

77. If you are given an insect, a spider, a Peripatus, and a crab, basing on which character you can identify an arachnid from others?

a. one pari of legs

b. sense organs

c. four pairs of legs

d. number of wings

78. Choanocytes perfom

a. reproduction

b. nutrition

c. dsecretion of spicules

d. excretion

79. Common characteristics of cockroach, housefly and mosquito are

a. one pair each of wings and halters

b. three pairs of legs and one pair of developed wings

c. two pair of legs and two compound eye

d. compound and simple eyes

80. The secondary host of *Taenia* is

a. snail **b. pig**

c.man d. dog

81. The exoskeleton of insect is made up of

a. pectin b. lignin

c. chitin d. suberin

82. Collar cells are found in

a. aschelminthes b. cnidaria

c. arthropoda **d. sponges**

83. Ommatidia are the units that constitute the compound eyes in (AMU 1995).

a. Fish **b. Insects**

c. Mammals d. birds

84. Which of the following animals possesses ink gland? (AMU 2003)

a. blue whale
b. scorpion
c. sea urchin
d. **cuttle fish**

85. Comb plates are present in (AMU 2004)

a. echinoderms
b. **ctenophores**
c. annelids
d. molluscs

86. Which of the following does not belong to phylum cnidaria?(AMU2004).

a. Sea-pen
b. **Sea lily**
c. Sea-fan
d. Sea anemone

87. Protonephridia are the excretory structures present in (AMU2005)

a. **Planaria**
b. Roundworm
c. Tapeworm
d. Prawn

88. Which of the following is not an annelid? (AMU2007)

a. Leech
b. Earthworm
c. Sea mouse
d. **Sea cucumbers**

89. Blood worms are the larvae of (AMU 2007)

a. Hirudinaria
b. **Chironomus**
c. Limulus
d. Daphnia

90. Pick the odd pair: (AMU 2008)

a. Porifera : spicules
b. **Scyphozoan: coral reef**
c. Nematode : pseudocoelomate
d. Cestoda: proglottid

91. Insect metamorphosis having larval stage is called (AFMC 1994)

a. Incomplete metamorphosis
b. Retrogressive metamorphosis
c. Heteromorphosis
d. **Complete metamorphosis**

92. Which of the following is not an insect? (AFMC 1996)

a. Cockroach b**. Spider**
c. Mosquito d. bedbug

93. Which of the following enters intestine by penetrating through skin (AFMC 2003)

a. **hook worm**
b. Ascaris
c. Pin worm
d. filarialworm

94. In nemathelminthes the coelom is not lined by peritoneum is (AFMC 2004)

a. acoelom
b. **pseudocoelom**
c. enterocoelom
d. haemocoel

95. Leech secretes which of the following anticoagulant? (AFMC 2004)

a. **hirudin** **b.** heparin
c. serotonin d. histamine

96. Canal system in porifera is not concerned with (AFMC 2005)

a. respiration
b. nutrition
c. **sexual reproduction**
d. none of these

97. Johnston's organ is present in (AFMC 2007)

a. **antenna of insect**
b. head of cockroach
c. abdomen of housefly
d. abdomen of spider

98. Which of the following is not an arachnid? (AFMC 2007)

a. spider b. itchmite
c. louse **d.** tick

99. *Fasciola hepatica* is (AFMC 2007)

a. hermaphrodite. Self fertilizing
b. hermaphrodite, cross fertilizing
c. unisexual
d. **both (a) and (b)**

100. Match the excretory organs listed under column I with the animals given under column II. Choose the answer which gives the correct combination of alphabets of the column.

Column I	Column II
A Nephridia	P *Hydra*
B Malpighian tubules	q Leech
C protonephridia	r Shark
D kidneys	s Round worms
	t Cockroack

a. A = q; B = t; C= s; D = r
b. A =s ; B= q; C= p; D= t
c. A = t; B = q; C = s; D = r
d. A = q; B = s ; C =t ; D= p

101. Entomology is concerned with the study of ….

a. formation and properties of soil
b. agricultural practices
c. various aspects of human life
d. various aspects of insects.

102. Which phylum of the animal Kingdom is exclusively marine? (orissa 2003,2006)

a. porifera b. arthropoda
c. echinodermata d. molluscs

103. Study of ticks and mites is

a. Acarology b. Entomology
c. Malacology d. Carcinology

104. Larva of mosquito is

a. maggot b. caterpillar
c. grub **d. none of these**

105. Transparent hairs on catkins and caterpillars function to ?

a. trap heat
b. trap moisture
c. reflect light
d. drink water.

106. Which of the following traits is not the characteristic of echinodermat?

a. water vascular system
b. trochophore larva
c. Aristotle's lantern
d. radial and indeterminate cleavage

107. which of the following is pseudocoelomate ?

a. nematode b. chordate
c. echinodermata d. arthropoda

108. Which is not correct for sponges ?

a. internal fertilization
b. external fertilization
c. gemmule formation
d. gametes are formed from epidermal cells.

109. Triploblastic , schizocoelic, unsegmented soft bodied animals belongs to the phylum (J&K 1998)

a. annelid **b. mollusca**
c. nemathelminthes d. none of the above

110. Which one of the following animals belongs to the phylum cnidaria ? (J&K1998)

a. silver fish b. *squid*

c. jelly fish d. *Echidna*

111. *Palaemon* (prawn) is a (J & K 2000)

a. fish b. insect

c. soft shell mollusc **d. crustacean**

112. Tapeworm occurs as a parasite in (J&K 2001)

a.liver b. stomach

c. intestine d. all of these.

113. What distinguishes an insects from crustacean ? (J&K 2002, 2005)

a. number of eyes

b. arrangement of nerve cords

c. number of appendages

d. presence of wings.

114. Leeches are usually (J&k 2005)

a. herbivorous b. insectivorous

c. carnivorous **d. sanguvorous**

115. *Wichereia bancrofit* is a common filarial worm. It belongs to the phylum (J&K 2007)

a. Platyhelminthes

b. Nemathelminthes

c. Annelid

d. Coelenterate

116. The dioecius animal is (J&K 2008)

a. Liver fluke **b. Aurella**

c. Tapeworm d. Earthworm

117. Malpighian tubles remove excretory products from

a. Mouth

b. Haemolymph

c. Oesophagus

d. Alimentary canal

118. Which of the following cell type is capable of giving rise to other cell types in sponges?

a. Pinacocytes

b. Archaeocytes

c. Thesocytes

d. Collencytes

119. The infective stage of *Entamoeba histolytica* is

a. **cyst**
b. spore
c. egg
d. **trophozoite**

120. Gonads of Obelia occur in

a. on blastocyst
b. inhydrula stage
c. **radial canals of medusa**
d. bases of entacles of medusa

121. Which one of the following features is common to leech, cockroach and scorpion?

a. nephridia
b. **ventral nerve cord**
c. cephalization
d. antennae

122. Excretory organs of flatworms are

a. Malpighian tubules
b. Neprons
c. **Protonephridia**
d. Nnepridia

123. Sea cucumbers belong to class

a. Echinoidea
b. **Holothuroidea**
c. Ophiuroidea
d. Asteroidean

124. One of the following is a very unique feature of the mammals (PMT2004, DPMT 1996. 1998)

a. Homeothermy
b. **Presence of diaphragam**
c. Four chambered heart
d. Rib cage

125. Uricotelisum is found in (PMT2004)

a. Mammals and birds

b. Fishes and fresh water protozoans
c. **Birds, reptiles and insects**
d. Frogs and toads

126. Which one of the following characters is not typical of the class mammalian? (PMT2004)

a. Thecodont dentition
b. Alveolar lungs
c. **Ten pairs of cranial nerves**
d. Seven cervical vertebrate

127. Which one of the following in birds, indicates their reptilian ancestry? (PMT 2008)

a. Two specialchambers crop and gizzard intheir digestive tract
b. Egs with a calcareous shell
c. **Scales on their hind limbs**
d. Four-chambered hear

128. Which one of the following pairs of animals comprises 'Jawless fishes'? (PMT2009)

a. Mackerals and rohu
b. **Lampreys and hag fishes**
c. Guppies and hag fishes
d. Lampreys and eels

129. Camouflage of chameleon is associated with (AIIMS1995)

a. Chromoplast
b. Chromosome
c. **Chromatophore**
d. Chromomere

130. In fast swimming fishes, propulsion is due to(AIIMS 2000)

a. Pelvic fin
b. Pectoral fin
c. Dorsal fin
d. **Caudal fin**

131. Body temperature of cold blooded animals (AIIMS2000)

a. Is constant
b. **Fluctuates with surrounding temperature**
c. Becomes very lowa. times
d. Is very cold

132. Which of the following is an egg laying mammal?(AIIMS2001)

a. Kangaroo
b. **Platypus**
c. penguin
d. whale

133. Which of the following are uricotelic animals? (AIIMS2002)

a. rohu and frog
b. camela. frog
c. **lizard and crow**
d. earthworm and eagle

134. Which of the following does not come under the class mammals?(AIIMS2007)

a. flying fox
b. hedgehog
c. manatee
d. **lamprey**

135. which of the following is concerned with the formation of urea in rabbit ?(BHU 1994,2007)

a. spleen
b. kidney
c. blood
d. **liver**

136. Lateral line is present in (BHU 1996)

a. **dog fish**
b. jelly fish
c. starfish
d. none of these

137. The largest and heaviest mammals in the world is (BHU1994)

a. **blue whale**
b. elephant
c. lion
d. tiger

138. Ichithyophis is a member of (AIIMS 1997)

a. **amphibian**
b. mollsca
c. reptilian
d. annelid

139. Renal portal system is absent in (AIIMS 1998,2008)

a. reptiles
b. amphibians
c. reptiles and amphibians
d. **birds**

140. Bone marrow is absent in (AIIMS 2000)

a. reptilian
b. amphibian
c. fishes
d. **birds**

141. Urea is formed in which organ in rabbit? (AIIMS 2001)

a. **liver**
b. kidney
c. spleem
d. lung

142. Which of the following is not classified amphibian?(AIIMS2003)

a. frog
b. salamander
c. **tortoise**
d. ichthiophis

143. The excretory material of bony fish is (AIIMS 2004)

a. urea
b. protein
c. **ammonia**
d. amino acid

144. Limbless amphibians belong to the order (AIIMS 2007)

a. anura
b. urodela
c. **gymnophiona**
d. lissamphibia

145. Which of the following snakes is non-poisonous?(AIIMS 2007)

a. cobra
b. krait
c. viper
d. **python**

146. Placoid scales are found in (AIIMS 2008)

a. reptilia
b. bony fishes
c. **cartilaginous fishes**
d. amphibians

147. Which of the following is a correct sequence of decreasing order of number of species? (AIIMS 2008)

a. aves, pisces, reptiles, amphibians, mammals
b. **pisees, aves, reptiles, mammals, amphibians**
c. pisees, mammals, reptile, amphibians, aves
d. amphibians aves, pisces, mammals, reptiles

148. Excretory organ in Balanoglossus are (DPMT 1991,2008)

a. nephridia
b. antennary gland
c. collar cord
d. **proboscis gland**

149. Reptiles share which of the following character with birds and mammals?(DPMT 1994)

a. **Amnion**
b. Homeothermy
c. Diaphragm
d. Hipple

150. Cowper's gland is present in (DPMT 1996)

a. Frog
b. Earthworm
c. **Rabbit**
d. Cockroach

151. Which of the following pairs belong to the category of cold blooded animals? (DPMT 1998)

a. bat & rate
b. snakes & birds
c. **frog & snakes**
d. birds & monke

152. The character of birds without exception is (UP-CPMT 1995)

a. omnivorous
b. **beak without teeth**
c. flying wings
d. lay eggs with calcareous shells

153. Quill feathersa. the base of quill wings are called (UP-CPMT 1995)

a. **remiges**
b. coverts
c. barbules
d. down feathers

154. Which of the following pair of orgaisms are uricotelic? (UP-CPMT 2000)

a. cartilaginous fishes and mammals
b. reptiles and mammals
c. **birds and insects**
d. bony fishes and lizards

155. In the urinogenital organs of rabbit which one of following part is present in male but not in female? (UP-CPMT 2005)

a. Urethra
b. Fallopian tube
c. Vagina
d. **Vas deferens**

156. Which one of the following features is present in some stage of the life history of all chordates? (UP-CPMT 2000)

a. Blood flowing forward in dorsal blood vessel
b. **Phyaryngeal gill slits**
c. A ventral hollow nerve cord
d. Heart lying dorsally

157. Thoracic cage in rabbit is made up of (UP-CPMT 2006)

a. Ribs, vertebral column & diaphragm
b. Ribs, diaphragm & sternum
c. Vertebral column, diaphragm & sternum
d. **Ribs, vertebral column & sternum**

158. Which of the following has exoskeleton of scales and paired copulatory organ or penis?(UP-CPMT 2007)

a. Sharks
b. **Lizards**
c. Urodela
d. Urochordata

159. Laterally compressed tail is found in

a. Fresh water snakes
b. Terrestrial snakes
c. Marine non-poisonous snakes
d. **Marine poisonous snakes**

160. Which of the following is characteristic feature of fishes?

a. Tail and venous heart
b. Epidermal scales and tail
c. **Venous heart and gills**
d. Epidermal scales and gills

161. Similarity between fish and tadpole is

a. Scales b. Legs
c. **Lateral line** d. Fins

162. Four-chambered heart is present in

a. frog
b. **crocodile**
c. shark
d. lizard

163. Right aortic arch is present in

a. reptiles only
b. mammals only
c. **birds only**
d. both birds and mammals

164. Kidney of adult reptiles are (AMU 1996)

a. measonephric
b. **metanephric**
c. pronephric
d. both (a) and (b)

165. Marine fishes drink sea water to (AMU 2001)

a. meet their body salt requirements
b. compensate loss of water from their body
c. flush out nitrogenous wastes from their body
d. **achieve all of the above**

166. In which of the following fishes the males have brood pouch, where eggs laid by the female remain till they hatch? (AMU 2002)

a. Lung fish
b. Climbing perch
c. Salmon
d. **Sea horse**

167. Match the names of branches of science listed under column- I with the field study given under column- II choose the choice which gives the correct combination of the alphabets. (AMU2000)

Colum – I (Branch of Science)	Colum –II (Field of study)

A	Mycology	p	Study of birds
B	Ornithology	q	Study of worms
C	Herpetology	R	Study of fishes
D	lethylogy	S	Study of fungi
		t	Study of reptiles

a. **A=s, B=p, C=t, D=r**
b. A=q, B=s C=r, D=t
c. A=s, B=t, C=p, D=r
d. A=p, B=s, C=r, D=t

168. Identify the edible fresh water teleosts (AMU2001)

a. Sharks
b. Rays and skates
c. Hilsa ilisha
d. **Catla catla**

169. Turtles are (AMU2002)

a. Pisces
b. **Repties**
c. Molluscans
d. Arthropods

170. Harversian systems are found in the bones of (AMU2002)

a. Pigeon
b. **Panther**
c. Pipe fish
d. Python

171. Choose the correct combination of alphabets which matches the zoological names given under column I with their common names given under clumnII(AMU 2002)

Column – I		Column –II	
A	Labeo rohita	E	Jungle fow I
B	Gallus gallus	F	Carp
C	Bos indicus	G	Tussar silkmoth
D	Antheraea mylitta	H	cattle

a. A=F, B=G, C=E, D=H
b. A=G, B=E C=H, D=F
c. **A=F, B=E, C=H, D=G**
d. A=F, B=E, C=G, D=H

172. Which of the following statements is true?(AMU 2003)

a. All chordates are vertebrates
b. **All vertebrates are chordates**
c. Invertebrates possess a tubular nerve cord
d. Nonchordates a have a vertebral column

173. Chosse the cat fish from the following (AMU 2004)

a. *Cirrhina mrigala*
b. ***Wallago attu***
c. *Labeo rohita*
d. *Catla catla*

174. A four chambered heart is not found in…….(AMU2004)

a. Mammals
b. Birds
c. **Snake**
d. Crocodile

175. Calotes versicolor is a (AMU 1997)

a. House lizard
b. Rock lizard
c. **Garden lizard**
d. Flying lizard

176. Scientific name of king cobra is (AMU 2002)

a. Naja naja
b. Amphiliabs
c. **Naja Hannah**
d. Vipera russelli

177. Branch of zoology dealing with the study of amphibians and reptiles is called (AMU 2003)

a. Ichthyology
b. Ornithology
c. **Herpetology**
d. Malacology

178. Adaptation of colour vision is found in (AMU 2006)

a. Mammals
b. Aves
c. Reptiles
d. **All of these**

179. Epidermal scale is the characteristic feature of class reptilian, which of the following class is without epidermal scale?(AMU2006)

a. Fish
b. Aves
c. Mammals
d. **Amphibians**

180. Duck-billed platypus is a connecting link between (AMU 2007)

a. Reptile & bird
b. Living andnonliving
c. **Reptile & mammal**
d. Echinodermata & chordate

181. Which of the following isa. egg laying mammal?(J&K 2005)

a. Dolphin
b. **Platypus**
c. Whale
d. Walrus

182. In sharks, one of the following is absent (J&K 2008)

a. Claspers
b. Placoid scales
c. Cartilaginous endoskeleton
d. **Air bladder**

183. Which one of the following animals belongs to cyclostomata? (J&K2008)

a. Channa
b. Loris
c. Dodo
d. **Pertomyzon**

184. Which of the following is dominant in desert?

a. **Lizard**
b. Tiger
c. Leopard
d. hyla

185. Two examples in which the nitrogenous wastes are excreted from body in the form of uric acid are

a. **birds and lizards**
b. insects and bony fishes
c. mammals andmolluscs
d. frogs andcartilaginous fishes

186. The arrangement of ear ossicles in mammalian ear is

a. stapes malleus, incus
b. **malleus, incus, stapes**
c. incus, malleus, stapes
d. columella, malleus, incus

187. Snake has

a. movable eyelids
b. **immovable eyelids**
c. no cyclids
d. eyelids in pouches

188. Which among these is correct combination of aquatic mammals? (NEET 2017)

a. Dolphins, seals, Trogon
b. Whales, Dolphin, Seals.
c. Trygon, Whales, Seals
d. Seals, Dolphin, Sharks.

189. In case of poriferance, the spongocoel is lined with flagellated cells called, (NEET 2017)

a. Oscula **b. Coenocytes**
c. Mesenchymal cells d. Ostia.

190. Which is the National Aquatic animal of India (NEET 2016)

a. River Dolphin b. Blue whale
c. Sea horse d. Gangetic shark

191. An important characteristic that Hemichordates share with chordates is (NEET 2017)

a. Ventral tubular nerve chord
b. Pharynx with gill slits.
c. Pharynx without gill slits.
d. Absence of notochord.

Chapter 3 ANIMAL TISSUES

1. Transitional epithelium occurs in : (MHTCET 2008)

a. Blood vessels
b. Trachea
c. Kidney
d. **Ureter/urinary bladder**

2. The study of tissues is known as : (MPPMT 2010)

a. Physiology
b. Ecology

c. **Histology**

d. Anatomy

3. Find out the wrong match :

a. Eosinophils Allergic response

b. Basophils Secrete histamine and serotonin

c. Monocytes Secrete heparin

d. Lymphocytes Immune response

4. The outer covering of cartilage is called. (WB 2010)

a. Peritoneum

b. Periosteum

c. Endosteum

d. **Perichondrium**

5. Skin is : (CPMT 2010)

a. Cubiodal epithelium

b. Stratified epithelium

c. Coloumnar epithelium

d. Pseudostratified epithelumn

6. Match the animals listed in column-I to blood listed in column-II. (KCET 2010) Column-I Column-II (P) Man (i) Plasma and cells are colourless (Q) Earth worm (ii) Plasma colourless and nucleated RBC (R) Cockroach (iii) Plasma colourless and enucleated RBC

(S) Frog (iv) Plasma red and nucleated colourless RBC

(v) Plasma and RBS have haemoglobin

a. (P-iii), (Q-iv), (R-i), (S-ii)

b. (P-iv), (Q-v), (R-iii), (S-ii)

c. (P-i), (Q-iv), (R-ii), (S-iii)

d. (P-v), (Q-iii), (R-i), (S-iv)

7. Matrix of bone and cartilage can be distinguished by the presence of :

a. Lacunae

b. Chromatophares

c. **Haversian canals**

d. Adipose cells

8. Which type of tissue forms glands : (MPPMT 2010)

a. Epithelial

b. Muscular

c. Nervous

d. Connective

9. Which of the following blood cells help in blood coagulation.

a. RBCs

b. Lymphocytes

c. **Thrombocytes**

d. Basophils

10. Fibroblasts macrophages and mast cells are present in :

a. Cartilage tissue

b. **Areolar tissue**

c. Adipose tissue

d. Glandular epithelium

11. Which type of epithelium is involved in a function to move particles or mucus in specific direction : (HPPMT 2010)

a. Squamous epithelium

b. Cuboidal epitheliumc.

c. Columnar epitheliumd.

d. Ciliatal epithelium

12. Which of these is not found in connective tissue : (MPPMT 2010)

a. Collagen fibres

b. **Basement membrane**

c. Hyaluronic acid

d. Fluid

13. Multi-lobed nucleus and granular cytoplasm are characteristics of which of the WBCs :

a. Neutrophils

b. Monocytes

c. Lymphocytes

d. Eosinophils

14. Which one of the following plasma proteins is involved in the coagulation of blood. (2011)

a. globulin

b**. Fibrinogen**

c. albumin

d. Serum amylase

15. Which of the following is not a connecting tissue. (CPMT 2010)

a. Blood

b. bone

c. Lymph

d**. Nerve**

16. The ciliated columnar epithelial cells in humans are knows to occur in.

a. Bile duct and oesophagus

b. Fallopian tubes and urethra

c. Eustachian tube and stomach lining

d. Bronchioles and fallopian tubes

Chapter 4 Organ And Organ Systems

1. The body cells in cockroach discharge their nitrogenous waste in the haemolymph mainly in the form of NEET 2015

a. Calcium carbonate

b. Ammonia

c**. Potassium urate**

d. Urea

2. Frog's heart when taken out of the body continues to beat for sometime. Select the best option from the following statements. NEET 2017

(a) Frog is a poikilotherm.

(b) Frog does not have any coronary circulation.

(c) Heart is "myogenic" in nature.

(d) Heart is autoexcitable Options:

(1) Only(d) (2) (a) and (b) **(3) (c) and(d)** (4) Only(c

Chapter 5

Digestion and Absorption

1. How pepsin is differing from trypsin ? (DPMT – 1993)

a. It digests protein in acidic medium

b. It digests protein in alkaline medium

c. It digests carbohydrate in acidic medium

d. It digests carbohydrate in alkaline medium

2. Human intestine large because….. (DPMT – 1996)

a. Bacteria in the food moves slowly

b. Substances of food digest slowly

c. It provide more space for the absorption of digested food

d. It provide more space for the storage of food

3. How the epidermal cells in the stomach of vertebrate animal is protect stomach against HCl ? (NCERT -1981)

a. HCl is dilute

b. Epidermal cells defense the function of HCl

c. HCL is neutralized in stomach

d**. Epidermal cells covered with secretion of mucous**

4. By what the major part of mammalian teeth is made up ? (CPMT – 1984)
   a. Root
   b. Pulp
   c. **Dentin**
   d. Enamel
5. Enterokinase takes part in the conversion of what ? (BHU-2000)
   a. Pepsinogen into pepsin
   b. **Trypsinogen into trypsin**
   c. Protein into polypetide
   d. Caseinogen into casein
6. Secretin stimulates production of (M.P.PM.T. 2002)
   a. Saliva
   b. Gastric juice
   c. Bile
   d. **Pencreatic juice**
7. Pepsin acts in (H.P.P.M.T.-2001)
   a. Basic medium
   b.Acidic meduim
   c. Neutral meduim
   d. All type of medium
8. Enzyme trypsin is secreted by (A.F.M.C. -2003)
   a. Duodenum
   b. Liver
   c. **Pancreas**
   d. Stomach
9. The number of teeth that grow twice in the human life is (A.F.M.C. -2002,2004)
   a. 4
   b. 12
   c. **20**
   d. 28
10. The number of teeth that grow once in the human life is (D.P.M.T, B.H.U.-1986)
    a. 4
    b. 12
    c. 20
    d. **28**
11. Cholesterol is synthesised in (M.P.P.M.T. – 2000)
    a. Brunner's glands
    b. Liver
    c. Spleen
    d. Pancreas
12. Largest gland in human body is (J.K. C.M.E.E- 2003)
    a. Liver
    b. Pancreas
    c. Pituitary
    d. Thyroid
13. Muscular contraction of alimentary canal are (C.M.C- 2003)
    a. Circulation
    b. Deglutition
    c. Churning
    d. **Peristalsis**
14. Fatty acids and glycerol are first absorbed by (B.V.- 2000)
    a. Lymph vessels
    b. Villi
    c. Blood capillaries
    d. Hepatic portal vein
15. Trypsin changes (M.P.P.M.T. – 1995)
    a. Proteins into peptones
    b. Fats into fatty acids
    c. Starch and glycogen into maltose
    d. Maltose into its components

16. Secretin hormone is produced by (M.P.P.M.T. – 1995)

a. Stomach

b. Liver

c. **Intestine**

d.Pancreas

17. Narrow distal part of stomach is (M.P.P.M.T. – 1995)

a. Cardiac

b. Pharynx

c. Duodenum

d. **Pylorus**

18. pH suitable for ptyalin actions is (A.F.M.C. -1996)

a. 6 – 8

b. 7 – 8

c. 3 – 2

d. 9 – 3

19. What will happen if bile duct gets choked ? (D.P.M.T. – 1996)

a. Faeces become dry

b. **Acidic chyme will not be neutralised**

c. There will be little digestion in intestine

d. Little absorption of fat will occur

20. Digestion of both starch and protein is carried out by (A.F.M.C. -1996)

a. Gastric juice

b. Gastric lipase

c. Pancreatic juice

d. Ptyalin

21. What is common among amylase, renin and trypsin ? (C. P. M.T. -2000)

a. All proteins

b. Proteolytic enzymes

c. Produced in stomach

d. Act at pH lower then 7

22. Enterokinase is (B.H.U. -1997)

a. Pancreatic hormone

b. Intestine hormone

c. Pancreatic enzyme

d. **Component of Intestinal juice**

23. Which enzyme initiates protein digestion ? (M.P. P. M.T. -1997)

a. Pepsin

b. Trypsin

c. Aminopeptidase

d. Carboxypeptidase

24. Enzyme which does not directly act upon food substrate is

a. Trypsin b. Lipase

c. Enterokinase d. Amylopsin

25. Pepsin is secreted by (CPMT-1997)

a. Peptic cells

b. Zymogen cells of stomach

c. Zymogen cells of duodenum

d. Pancreas

26. Pepsinogen is activated by

a. Chymotrypsin

b. Trypsin

c. HCl

d. Pepsin

27. Contraction of gall bladder is induced by

a. Gastrin

b. Cholecystokinin

c. Secretin

d. Enterogastrone

28. Hormone that stimulates stomach to secrete gastric juice is

a. Renin

b. Enterokinase

c. Enterogastrone

d. Gastrin

29. Water is largely absorbed in (C. P. M.T. -1999)

a. Stomach

b. Oesophagus

c. Small intestine

d**. Colon**

30. HCl is secreted by (D. P. M.T. -2002)

a. Zymogen cells

b. Kupffer's cells

c. Oxyntic cells

d. Mucous cells

31. Jundice is a disease of (A. P. M.E.E. -1999)

a. Kidney

b. Liver

c. Pancreas

d. Duodenum

32. Which is different ? (B.H.U. -1999)

a. Gastrin

b. Secretin

c. Ptyalin

d. Glucagon

33. Gastrin is (B.H.U. -1999)

a. Hormone

b. Enzyme

c. Nutrient

d. Digestive secretion

34. Saliva contains enzyme (C. P. M.T. -2003)

a. Enterokinase

b. Ptyalin/ Amylase

c. Chymotrypsin

d. Lipase

35. In human being cellulose is digested by

a. Enzyme

b**. Symbiotic bacteria**

c. Symbiotic protozoans

d. None of the above

36. Enzyme lactase occurs in (M.P.P.M.T. -2000)

a. Saliva

b. Pancreatic juice

c. Intestinal juice

d. Stomach

37. Protein / enzyme is absent in (M.P.P.M.T. -2000)

a. Saliva

b. Bile

c. Pancreatic juice

d.Intestinal juice

38. Dental formula shows (M.P.P.M.T. -2000)

a. Structure of teeth

b. Monophyodont or diphyodont condition

c. Number and type of teeth in both jaws

d. Number and type of teeth in one half of both jaws

39. pH of gastric juice / stomach is

a. 1.5 -3.0

b. 5.0 – 6.8

c. 7.0 – 9.0

d. 6.0 -8.0

40. In case of taking food rich in lime juice, the action of ptylin on starch is (A.I.I.M.S. -2000)

a. Enhanced

b. Reduced

c. Unaffected

d. Stopped

41. Bile salts take part in (A.M.U. -2000)

a. Digestion of carbohydrates

b. Brokedown of proteins

c. Emulsification of fat

d. Absorption of glycerol

42. Digestive juice contains catalytic agents called (P.M.T. -2000)

a. Vitamins

b. Hormones

c. **Enzymes**

d. Nitrates

43. Which is not the function of liver (D.P.M.T. -2001)

a. Production of insulin

b. Detoxification

c. Storage of glycogen

d. Production of bile

44. Fat absorbed from gut is transported in blooda.

a. Micelles

b. Liposomes

c. Chemomicrons

d. Chlymicrons

45. In small intestine, active absorption occurs in case of (A.M.U. -2001)

a. Glucose

b. Amino acids

c. Na+

d. **All the above**

46. Which one is not matched (Har.P.M.T. -2002)

a. Pepsin – stomach

b. Renin – liver

c. Trypsin – intestine

d. Ptyalin – mouth

47. What is cholecystokinin

a. Bile pigment

b. Gastro-intestinal hormone

c. Enzyme

d. Lipid

48. Secretion of gastric juice is controlled by (C.P.M.T. -2002)

a. Enterogesterone

b. Cholecystokinin

c. **Gastrin**

d. Pepsin

49. Which one is wisdom teeth (C.P.M.T. -2002)

a. Third molar, four in number

b. Third molar, two in number

c. Second molar, four in number

d. Second molar, two in number

50. In humans, digestion is (B.H.U. -2002)

a. Intercellular

b. Intracellular

c. Extracellular

d. Both A and B

51. Gall bladder takes part in (R.P.M.T. -2002)

a. Secretion of bile

b. Storage of bile

c. Formation of bile salts

d. Formation of enzymes

52. Rennin acts on milk protein and changes (J.I.P.M.E.R. -2002)

a. Caesinogen into caesin

b. Caesin into paracaesin

c. Caesinogen into paracaesin

d. Paracaesin into Caesinogen

53. Glucose is stored in liver as (A.F.M.C. -2003)

a. Starch

b**. Glycogen**

c. Cellulose

d. Sucrose

54. Absorption of glycerol, fatty acids and monoglycerides takes place by

a. Lymph vessels within villi

b. Walls of stomach

c. Colon

d. Capillaries within villi

55. Which ones are bile salts

a. Haemoglobin and biliverdine

b. Bilirubin and biliverdine

c. Bilirubin and Haemoglobin

d. Sodium glycolate and taurocholate

56. Ptyalin is inactivated by a component of gastric juice called (Har.P.M.T. -2003)

a. Pepsin

b. HCl

c. Rennin

d. Mucus

57. Epithelial cells involved in absorption of digested food have on their free surface. (A.I.E.E.E.-2003)

a. Zymogen granules

b. Pinocytic vesicles

c. Phagocytic vesicles

d**. Microvilli**

58. First step in digestion of fat is (B.H.U. -2003)

a. Emulsification

b. Enzyme action

c. Absorption by lacteals

d. Storage in adipose tissue

59. DNA-ase and RNA-ase are enzymes produced by (B.H.U. -2003)

a. Salivary glands b**. Pancreas**

c. Stomach d. Intestine

60. Carboxypeptidase is secreted by

a. Pancreas

b. Stomach

c. Salivary glands

d. Intestine

61. Secretin and Cholecystokinin are digestive hormone, They are secreted in

a. Pyloric stomach

b**. Duodenum**

c. Ileum

d. Oesophagus

62. Crown of teeth is covered by (AFMC-2005)

a. Dentin

b**. Enamel**

c. A and B both

d. Non of these

63. Both the crown and root of a theeth is covered by a layer of bony hard sub stance called (J&K CET-2005)

a. Enamel

b. Dentin

c. Bony socket

d**. Cementum**

64. Lysozymes are found in (MPPMT-2004)

a. Saliva

b. Tears

c**. A and B both**

d. Mitochondria

65. Which of the following is not present in pancreatic juice (HPPMT-2005)

a. Trypsinogen

b. Chymotrypsin

c. Parasitic

d. lipase

66. Which of the following statement is not correct ?(NEET 2015)

a. Bruner's glands are present in the submucosa of stomach and secrete pepsinogen

b. Goblet cells are present in the mucosa of intestine and secrete mucus.

c. Oxyntic cells are present in the mucosa of stomach and secrete Hcl.

d. Acini are present in the pancreas and secrete carboxypeptidse.

67. Which hormonesd. stimulate the production of pancreatic juice and bicarnates ? **(NEET 2016)**

a. Cholycystokinin and secretin

b. Insulin and glucogon

c. Angiotensin and epinephrine

d. Gastrin and Insuline

68. In the stomach, gastric acid is secreted by the (AIPMT / NEET 2016)

a. Gastrin secreting cells
b. **parietal cells**
c. peptic cells
d. acidic cells

69. The enzymes that is not present is succus entericus is (RE-AIPMTNEET 2015)

a. Lipase
b. maltase
c. **nucleases**
d. nucleosidase

70. Which of the following are not polymerase? (NEET 2017)

a. proteins
b. Polysaccharides
c. **Lipids**
d. Nucleic acids.

71. A baby aged two years is admitted to play school and passes through a dental check-up . The dentist observed that the boy had twenty teeth . Which teeth were absent. **(NEET 2017)**

a. Canines
b. **Pre- Molars**
c. Molars
d. Incisors.

72. Which cells of Crypts of Lieberkuhn' secrete antibacterial lysozyme ? **(NEET 2017)**

a. **paneth cells**
b. Zymase cells
c. Kupffer cells.
d. Argentaffin cells

73. The hepatic portal veins drains blood to liver from (NEET 2017)

a. Stomach b. Kidneys

c. Intestine d. Heart.

74. Which of the following options best represents the enzyme composition of pancreatic juice? **(NEET 2017)**

a. 1.Amylase, pepsin, trypsinogen, maltase

b. Peptidase, Amylase, pepsine , renine

c. Lipase, amylase, trypsinogen, procarboxypeptidase

d. Amylase, peptidase, trypsinogen, rennin.

75. Good vision depends on adequate intake of carotene rich food. Select the best option from the following statements. (NEET 2017)

a. Vitamin A derivatives are formed from carotene.

b. The photo pigments are embedded in the membrane discs of the inner segments.

c. Retinal is a derivative of vitamin A

d. Retinal is light absorbing part of all the visual photopigments.

OPTION

a. a, c and d

b. a and c.

c. b, c and d

d. a and b

Chapter 6

Respiration

1. The length of human trachea is about (Gujarat C.E.T.Q.B.)

   a. 6 inches b**. 12c.**
   c. 12 inches d. 18 cm

2. Hamburger's phenomenon is also known as (CPMT.1988, 1991,AMU.2001,J.LPME.R.2002)

   a. HCO3 – shift b. Na+ shift

   c. H+ shift d**.Chloride shift**

3. Oxygen carrying capacity of blood is (CPMT.1990)

   a. 20% b. 30%

   c. 40% d. 50%

4. Respiratory movements are controlled by (A.P.M.E.E.1978, C.P.M.T.1998)

   a. Cerebelluam

   b. Cerebrum

   c**. Medulla oblongata**

   d. Crura cerebri

5. At higher CO2 condtcentration, oxygen dissociation curve of haemoglobin will (CPMT.1990)

   a. Move to left

   b**. Move to right**

   c. Become irregular

   d. Move upwardly

6. Chloride shift is required for transport of (CPMT.1990)

   a. Nitrogen b. Oxygen

   c**. Carbon dioxide**

   d. Carbon dixide and oxygen

7. Volume of air inspired or expired with each normal breath is known

   a. (CMPT.1992,AMU.2000)

   a. Inspiratory capacity

   b. Total Lung capacity

   c**. Tidal volume**

   d. Residual volume

8. Oxygen haemoglobin dissociation curve will shift to right on decrease of (AMU.1992)

   a. Acidity

   b. Carbon dioxide concentration

   c. Temperature d. **pH**

9. Is Double membrane pleural sac is situated…… (J.K.C.M.E.E.1992)

   a. Envelops the kidneys

   b. Envelops the brain

   c. Envelops the lungs

   d. Lines the nasal passage

10. Volume of air remaining in lungs after maximum respiratory effort is (J.K.C.M.E.E.1992,Har.PMT.2003)

    a. Vital capacity

    b**. Residual volume**

    c. Total lung capacity

    d. Tidal volume

11. In expiration, diaphragm becomes (C.P.M.T.1993)

    a. Flattened

    b**. Relaxed**

    c. Straightened

d. Arched

12. Carbon dioxide is transported from tissues to respiratory surface by only

a. Plasma and erythrocytcs

b. Plasma

c. Erythrocytes

d. Erythrocytes and leucocytes.

13. Respiratory centre is situated in CPMT.1980,2002, B.H.U.1995,M.P.P.M.T.1998,R. PMT.2006)

a. Cerebellum

b**. Medulla oblongata**

c. Hypothalamus

d. Cerebrum

14. Air is breathed through (A.P.M.E.E.1 999)

a. Trachea -> lung -> larynx -> pharynx -> alveoli

b. Nose -> larynx -> pharynx -> alveoli -> bronchioles

c. Nostrils -> pharynx -> larynx -> trachea -> bronchi -> bronchioles -> alveoli

d. Nose -> mouth -> lungs.

15. Which is false ?

a. Blood from right side of heart is carried to lungs by pulmonary artery

b. Pleura is double covering of kindey

c. Pancreas is both exocrine & endocrine gland

d. Scurvy is due to vitamin C deficiency.

16. Volume of air breathed in and out during effortless respiration is

a. residual volume

b. vital volume

c.tidal volume

d. normal volume

17. Body tissue obtain oxygen from haemoglobin due to its dissociation in tissues is caused by (M.P.PMT.1995)

a. Low oxygen concentration and high carbon dioxide concentration

b. Low oxygen concentration

c. Low carbon dioxide concentration

d. High carbon dioxide concentration.

18. Lungs have a number of alveoli for (M.P.PMT.1995)

a. Having spongy texture and proper shape

b. More surface area for diffusion of gases

c. More space for increasing volume of inspired air

d. More nerve supply.

19. Presence of large number of alveoli around alveolar ducts opening into bronchioles in mammalian lungs is

a. Inefficient system of ventilation with little of residual air

b. Inefficient system of ventilation with high percentage of residual air

c. An efficient system of ventilation with no residual air

d. An efficient system of ventilation with little residual air.

20. During transport of CO_2 blood does not become acidic due to

a. Neutralisation of H_2CO_3 by Na_2CO_3

b. Absorption by leucocytes

c. Blood buffers

d. Non accumulation

21. At high altitude, RBCs of human blood will (PMT.1999,J. LPM.E.R.2000)

a. Increase in number

b. Decrease in number

c. Decrease in size

d. Increase in size

22. CO2 is transported

a. dissolved in blood plasma

b. As carbonic acid

c. In carbaminohaemoglobin

d. **As carbaminolaemoglobin and carbonic acid**

23. Maximum amount 70-75% of carbon dioxide transport occursa. (R.P.M.T.1996,1998,M.P.PMT.1998, C.P.M.T.1998,B.V.2002)

a. Dissolved in plasma

b. Carbaminohaemoglobin complex

c. Bicarbonate

d. None of the above

24. Trachea is lined with incomplete rings of (D.P.M.T.1996)

a. Fibrous cartilage

b. Calcified cartilage

c. Elastic cartilage

d. **Hyaline cartilage**

25. Oxygen and carbon dioxide are transported in blood through

a. Platelets and corpuscles

b. RBCs and WBCs

c. WBCs and serum

d. **RBCs and plasma**

26. About 1500 ml of air left in lungs is called

a. Tidal volume

b. Inspiratory reserve volume

c. Residual volume

d. Vital capacity

27. Which one protects the lungs? (B.H.U.1990)

a. Ribs

b. Vertebral column

c. Sternum

d. **All the above**

28. Which one has the lowest value?

a. Tidal volume

b.Vital capacity

c. Inspiratory reserve volume

d. Expiratory reserve volume

29. A child was killed through asphyxiation. Post morturm confirmed it because a piece of lung put in water (M.P.PMT.1996)

a. Settled dowm

b. **Kept floating**

c. Had blood spots

d. None of the above

30. Amount of oxygen present in one gram of haemoglobin is (A.I.I.M.S.1997,Har.PMT,2000)

a. 20 ml b. **1-34 ml**

c. 13-4 ml c. None of the above

31. A molecule of haemoglobin carries how many oxygen molecules (M.P.P.M.T.1997,C.F.M.T.2002,J. CM.E.E.2004)

a. 1 b.2 c. 3 d. **4**

32. In carbon monoxide poisoning there is (A.F.M.C 1997)

a. Increase in carbon dioxide concentration

b. Decrease in oxygen availability

c. Decrease in free haemoglobin

d. None of the above.

33. Exchange of gases in lung alveoli occurs through (A.FMC.2002)

a. Active transport

b.Osmosis

c.Simple diffusion

d. Passive transport

34. Haemoglobin is

a. Vitamin b. Skin pigment

c. Blood carrier **d.Respiratoy pigment**

35. Vocal cords occur in

a.Pharynx b**. Larynx**

c.Glottis d. Bronchial tube

36. The cells which do not respire (A.FMC.2001)

a. Epidermal cells b. Sieve cells

c.Cortical cells **d.Erythocytes**

37. Hiccough (hiccup) is due to activity of

a.Intercostal muscles

b. Food in air tract

c. Diaphragm

d. Inadequate oxygen in environment

38. Bicarbonate formed inside erythrocytes moves out to plasma while chloride of plasma pass into erythrocytes. The phenomenon is called

a. Bicarbonate shift

b. Carbonation

c. Hamburger phenomenon

d. None of the above

39. Respiratory centre of brain is stimulated by (A.I.I.M.S 2000)

a. Carbon dioxide content in venous blood

b. Carbon dioxide content in arterial blood

c. Oxygen content in venous blood

d. **Oxygen content in arterial blood**

40. A higher CO_2 concentration of blood causes (AM U.2001)

a. Slow diffusion of CO_2 from blood

b. Slow transport of CO_2 from blood

c. Slow diffusion of O_2 from blood

d. Both A and B

41. Gases diffuse over the respiratory surface because of

a. O_2 is more in alveoli than in blood

b. O_2 is more in blood than in tissues

c. CO_2 is more in alveoli than in blood

d. PCO_2 is more in blood than in tissues

42. Dissociation curve of O_2 (which is dissociation from Hb) shifts to the rights….

a. O_2 concentration decrease

b. CO_2 concentration decreases

c. CO_2 concentration increase

d. Chloride concentration increases

43. Thoracic cage of man is formed of (M.P.P.M.T.2002)

a. Ribs and sternum

b. Ribs, sternum and thoracic vertebrae

c. Ribs,sternum and lumbar vertebrae

d. Ribs and thoracic vertebrae.

44. Vital capacity of lung is equal to

a. IRV+ERV+TV

b. IRV+ERV+TV-RV

c.IRV+ERV+TV+RV

d.IRV+ERV

45. Dead space is

a. Upper respiratory tract

b. Nasal chambers

c. Alveolar space

d. Lower respiratory tract.

46. Carbon monoxide contained in Tobacco smoke (A.I.E.E.E.2003)

a. Is carcinogenic

b. Causes gastric ulcers

c. Reduces oxygen carrying capacity of blood

d. Raises blood pressure

47. What is correct ?

a. Pulomonary ventilation is equal to alveolar ventilation

b. Alveolar ventilation is less than pulmonary ventilation

c. Alveolar ventilation is more than pulmonary ventilation

d. Both are variable.

48. Increase in CO_2 concentration shall cause

a. Slower and shallower breathing

b. Slower and deeper breathing

c. Faster and deeper breathing

d. No effect on breathing

49. Alveoli become enlarged and damaged with reduced surface area in heavy smokers. the condition is called

a. Silicosis b**. Emphysema**

c. Asthma d. Bronchitis

50. SARS is caused by a variant of (A.I.I.M.S 2004)

a. Pneumococcus pneumonia

b. Common cold by Corona virus

c. Asthma d. Bronchitis

51. During inspiration (J.I.PME.R.2004,R.PMT.2005)

a. Diaphragm and external muscles relax

b. Diaphragm and internal intercostal muscles relax

c. Diaphragm and external intercostal muscles contract

d. Diaphragm and internal intercostal muscles contract.

52. Mountain sickness at high altitude is due to (C.P.M.T.2005)

a. Excess CO2 in blood

b. Decreased CO_2 in air

c. Decreased partial pressure of oxygen

d. Decreased efficiency of haemoglobin

53. Capacity of human lungs for air in a healthy person is

a. 3000 ml

b. 1500 ml

c. 1000 ml

d. 500 ml

54. Rate of breathing is controlled by

a. Amount of freely avilable oxygen

b**. Carbon dioxide in blood**

c. Muscular functions of body

d. All the above

55. During strenous exercise,glucose is converted into (B.H.U.2005)

a. Glycogen

b. Pyravic acid

c. Starch

d. **Lactic acid**

56. How much pulmonary air is expired normally (Har.P.M.T.2005)

a. 70% b. 20%

c. 25% d. **32%**

57. Which is incorrect ?

a. Presence of nonrespiratory air sacs increases efficinency of respiration in birds

b. In insects, circulation body fluids serve to distribute oxygen to tissues

c. Principle of counter – current flow facilitates efficient respiration in gills of fishes

d. Residual air in lungs slightly decreases the efficiency of respiration in mammals

58. Percenatage of oxygen being carried by blood plasma is

a. 6-9% b. 3-6%

c. 2-3% d. 1-2%

59. Name of the pulmonary disease in which alveolar surface area involved in gas exchange is drastically reduced due to damage in the alveolar walls: (RE-NEET 2015)

a. Astthma b. Pleurisy

c. Emphysema d. Pneumonia

60. Asthma may be attributed to (AIPMT/NEET 2016)

a. bacterial infection of the lungs

b. allergic reaction of the mast cells in the lungs

c. inflammation of the trachea

d. accumulation of fluid in the lungs

61. Name the chronic respiratory disorder caused mainly by cigarette smoking: (RE-NEET 2016)

a. Emphysema b. Asthma

c. Respiratory acidosis

d. Respiratory alkalosis

62. Lungs are made up of air-filled sacs, the alveoli. They do not collapse even after forceful expiration. (NEET 2017)

a. Inspiratory Reserve Volume

b. Tidal Volume

c. Expriatory Reserve Volume

d. Residual Volume

Chapter – 7

BODY FLUIDS AND CIRCULATION

1. What is the life span of RBC in humans ? (AFMC – 90)

   a. 120 days b. 210 days

   c. 220 days d. 200 days

2. What is found in the surrounding of wall of heart ? (AFMC – 93)

   a. Pericardial cavity b. Perineural cavity

   c. Pericardium d. None of the above

3. By which cause Dubb sound arises ? (CBSC-94)

   a. Closing of semilunar valve

   b. Closing of bicuspid valve

   c. Closing of tricuspid valve

   d. Both b and c

4. Which is the pacemaker heart ? (CBSC – 94)

   a. AV Node **b. SA Node**

   c. Purkinje fiber d. Bundle of His muscle

5. Where granular WBCs are produced ? (DPMT-95)

   a. Kidney

   b. Liver

   c. Small interstine

   d. Bone marrow

6. Which type of WBCs are found in maximum number ?

   a. Monocytes b. Basophils

   c. Acidophils **d. Neutrophils**

7. Which of the following is not useful in blood clotting. (AFMC-96)

   a. Fibrin b. Calcium

   c. Platelets **d. Bilirubin**

8. In which of the following close circulation is found ? (CBSC-94)

   a. Cockroach b. Mosquito

   c. Housefly **d. Tadpole**

9. The wall of which part of the heart is very thich ? (AIIMS-99)

   a. Left atrium **b. Left ventricle**

   c. Right atrium d. Right ventricle

10. What is right for all veins ? (CBSC-2000)

    a. They carry oxygenated blood

    b. They carry Deoxygenated blood

    c. They directly open into vena cave

    d. None of the above

11. How lymph differs from blood ? (CPMT – 73,84)

    a. More RBC and less WBC

    b. Less RBC and more WBC

    c. RBC absent and less RBC

    d. RBC absent and more WBC

12. Which type of WBCs are found in maximum number ? (CPMT-88, DPMT -96)

    a. Eosiophil **b. Nutrophil**

    c. Acidophil d. Monocyte

13. What is pacemaker ?

    a. Instrument measuring Heartbeats

    b. Instrument measuring big arteries

    c. Atrio – ventricular node, which provides stimulation for heart beating

    d. Artificial sinuauricular node, which provides stimulation for heart beating

14. Which of the following statement is correct ? (BHU-93)

a. All veins carry deoxygenated blood

b. All arteries carry deoxygenated blood

c. All veins carry deoxygenated blood except one

d. All arteries carry deoxygenated blood except one

15. Regulation and initiation of heartbeat is indicated by

a. AV Node – bundle of His muscule – SA node – purkinje fiber

b. SA Node – purkinje fiber – AV Node – Bundle of His muscle

c. Purkinje fiber – AV Node – SA node – Bundle of His muscle

d. SA Node – AV Node – Bundle of His muscle – Purkinje fiber

16. Where Mitral valve is located and it join, (BHU-86, 2000, DPMT-86)

a. Left atrium and left ventricle

b. Left atrium and Right ventricle

c. Right atrium and Left ventricle

d. Right atrium and Right ventricle

17. What is responsible for systole ? (BHU-86,2000,DPMT-86,)

a. Entry of blood in lungs

b. Entry of blood in heart

c. Blood flow out of heart

d. Blood flow out of vein

18. What is the function of lymph ? (MPPMT-95)

a. Transport of O2 into brain

b. Transport of CO2 into lungs

c. Bring interstitial fluid in blood

d. Bring RBC and WBC in lymph node

19. Which is the correct statement for blood ? (APMEE – 96)

a. WBC is more than RBC

b**. RBC is more than WBC**

c. RBC is less than platelets

d. Platelets is less than RBC

20. Hepatic portal system starts from

a. Digestive system to liver

b. Kidney to liver

c. Liver to heart

d. Liver to Kidney

21. Blood circulation that stats in capillaries and ends in capaillaries is called (J & K CET 2010)

a. Portal circulation

b. Hepatic circulation

c. Cardic circulation

d. None of these

22. Which of the following carries glucose from digestive tract to liver (PMT-1999,BHU 2001)

a. Hepatic artaery

b. Hepatic portal vein

c. Pulmonary vein

d. None of these

23. Lymph (nodes) glands form

a. Hormones

b. Lymphs

c. Antigens

d**. Antibodies**

24. Which of the following is not a major organ of lymphatic system (MP PMT 2010)

a. Lymph nodes b. Thymus

c**. Kidney** d. Spleen

25. Lymph is colourless because (MP PMT 1999)

a. WBC are absent

b. WBC are present

c. **Heamoglobin is absent**

d. RBC are absent

26. Immunoglobulins are produced by

a. Lymphocytes b. Spleen

c. Leucocytes d. Monocytes

27. Which of the following human organs is often called the "graveyard" of RBC ? (AIIPMT 2012-M)

a. Spleen b. kidney

c. Pancreas d. Liver

28. There is no DNA in

a. Mature RBCs

b. Mature spermatozoa

c. Hair root

d. Ovum

29. In the ABO system of blood groups, if both antigens are present but no antibody, the blood group of the individual would be ? (AIPMT 2011)

a. B b. O **c. AB** d. A

30. Which of the following are granular WBCs ?

a. Neutrophils,Basophils, Lymphocytes

b. Eosinophil, Basophil, Monocytes

c. Basophils, Monocytes, Lymphocytes

d. **Neutrophils, Eosinophils, Basophils**

31. What P indicates in ECG ?

a. End of atrium systole

b. **Starting of atrium systole**

c. End of ventricle systole

d. Starting of ventricle systole

32. Reduction in pH of blood will. (AIPMT/NEET 2016)

a. reduce the rate of heart beat

b. reduce the blood supply to the brain

c. **decrease the affinity of hemoglobin with oxygen**

d. release bicarbonate ions by the liver

33. Blood pressure in the pulmonary artery is. (AIPMT/NEET 2016)

a. same as that in the aorta

b. more than that in the carotid

c. more than that in the pulmonary vein

d. less than that in the venae cavae

34. A decrease in blood pressure/volume will not cause the release of. (NEET 2017)

a. Atrial natriuretic factor

b. Aldosterone

c. ADH

d. Renin

பாடம் 1 : உயிருலகு - Living world	
Diversity	பல்லுயிரியல்பு / பல்லுயிர்த்தன்மை
Systematics	இனத்தொடர்பு தொகுப்பமைவு
Hierarchy	படிநிலை
Nomenclature	பெயரிடும்முறைகள்
Biodiversity	பல்லுயிர் தன்மை
Autotrophic	தன்னூட்டம் ஊட்டமுறை
Phylogenentic tree	பரிணாம மரம்
Heterotrophic	சார்ந்துண்ணிகள், பிறஊட்ட உயிரிகள்
Thermoacidophiles	வெப்பம் மற்றும்அமிலத்தன்மையை தாங்கி வளரும் தன்மை
Tautonymy	பேரினப்பெயரும்/ சிற்றினப் பெயரும் / ஒரே மாதிரியாக இருத்தல்
Bioluminescence	உயிர் ஒளிர்தல்
பாடம் 2 : விலங்குலகம் - Animal kingdom	
Pinacocytes	கடற்பஞ்சுகளின் தட்டையான புறப்படை செல்கள்
Diploblastic animals	ஈரடுக்கு விலங்குகள்
Asymmetryical	சமச்சீரற்ற தன்மை
Radial symmetry	ஆரசமச்சீர் அமைப்பு
Biradial symmetrical	இரு ஆரசமச்சீர்
Para zoa	தளர்ச்சியான பலசெல்
Eumetazoa	பல செல் உயிரிகள்
Mesoglea	மீசோகிளியா
Deutrostomia	மூலக்குழியிலிருந்து மலவாய் தோன்றுதல்
Cnidocytes(or) cnidoblasts	கொட்டும் செல்கள்
Polyembryony	பல கருநிலை
Haemocoel	இரத்தம் உடற்குழி
Water vascular system	நீர் குருதியோட்ட மண்டலம்
பாடம் 3 : விலங்குத் திசுக்கள் – Animal tissues	
Epithelial tissues	எபிதீலிய திசுக்கள்
Connective tissues	இணைப்புத்திசுக்கள்
Muscular tissues	தசைத்திசுக்கள்
Neural tissues	நரம்புத்திசு
Squamous epithelium	தட்டை வடிவ எபிதீலியம்
Cuboidal epithelium	கனசதுர வடிவ எபிதீலியம்
Columnar epithelium	தூண் வடிவ எபிதீலியம்
Ciliated epithelium	குறுஇழை கொண்ட எபிதீலியம்
Compound epithelium	கூட்டு
Simple epithelium	எளிய
Pseudostratified epithelium	பொய் அடுக்கினால் ஆன எபிதீலியம்
Stratified epithelium	அடுக்கு எபிதீலியம்
Histology	திசுவியல்
Basic/Primary tissue	அடிப்படை திசு
பாடம் 4 : Organ and organ syste in Animals	
Worm castings	நாங்கூழ் கட்டிகள்
Epigeics	மேல்மட்ட புழுக்கள்
Anecics	நடு மட்ட புழுநக்கள்
Endogeics	அடிமட்ட புழுக்கள்

Peristomium	பெரிஸ்டோமியம்
Prostomium	புரோஸ்டோமியம்
Pygidium	பைஜிடியம்
Clitellum	கிளை டெல்லம்
Seta	சீட்டா
Coelomic fluid	உடற்குழி திரவம்
Sperma theca	விந்து கொள்பை
Nephridia	நெஃப்ரிடியா
Genital opening	இனப்பெருக்கத்துளை
Gizzard	அரைவைப்பை
Intestinal caeca	குடல் பிதுக்கங்கள்
Hydrostatic skeleton	நீர்ம சட்டகம்
Regeneration	இழப்பு மீட்டல்
Commissural vessels	இணைப்பு நாளங்கள்
Ganglion	நரம்பு செல்திரள்
Photoreceptor	ஒளி உணர்வி
Gustatory receptor	சுவை உணர்வி
Olfactory receptor	நுகர் உணர்வி
Tactile receptor	தொடு உணர்வி
Chemoreceptor	வேதிஉணர்வி
Thermo receptor	வெப்ப உணர்வி
Cocoon	புழுக்கூடு
Vermiwash	மண்புழு செறிவூட்டப்பட்ட நீர்
பாடம் 5 : செரித்தல மற்றும் உட்கிரகித்தல் Digestion & Absorption	
Digestive system	செரிமான மண்டலம்
Digestive glands	செரிமான சுரப்பிகள்
Salalivary glands	உமிழ்நீர் சுரப்பிகள்
Liver	கல்லீரல்
Pancreas	கணையம்
Gastro intestinal hormones	இரைப்பை–குடல் ஹார்மோன்கள்
Digestive enzymes	செரிமான நொதிகள்
Absorption	உட்கிரகித்தல்
Assimilation	தன்மயமாதல்
Protein	புரதங்கள்
Carbohydrates	கார்போஹைட்ரேட்டுகள்
Fats	கொழுப்புப் பொருட்கள்
Egestion	கழிவு வெளியேற்றம்
Nutrients	உணவூட்டப்பொருட்கள்
Minerals	கனிமங்கள்/ தாது உப்புகள்
Caloric value	கலோரி மதிப்பு
Malnutrition	ஊட்ட குறைவு
Indigestion	செரிமானம்
Constipation	மலச்சிக்கல்
Jaundice	கல்லீரல் அழற்சி, மஞ்சள் காமாலை
Peptic ulcer	இரைப்பை புண்
Appendicitis	குடல்வால் அழற்சி
Hiatus hernia	குடல் இறக்கம்
Autotrophs	தன்னூட்ட உயிரிகள்
Electrolytes	மின்பகுபொருட்கள்

Digestive juice	செரிமான திரவம்
Heterotroph	சார்ந்துண்ணிகள்
Foregut	முன்உணவுப்பாதை
Midgut	நடு உணவுப்பாதை
Hidgut	பின் உணவுப்பாதை
Buccal cavity/oral cavity	வாய்க்குழி
Terminal sulcus	முனைப்பள்ளம்
Cardial portion	இரைப்பை மேல்பகுதி
Fundic portion	இரைப்பை நடுப்பகுதி
Puloric portion	இரைப்பை பின்பகுதி
Duodenum	முன்சிறுகுடல்
Cardiac sphincter	கார்டியாக் சுருக்குத்தசை
Pyloric sphincter	பைலோரிக் சுருக்குத்தசை
Regurgitation	மீளத்திரும்புதல்
Gastric rugae	இரைப்பை உட்புற மடிப்புகள்
Jejunum	நடுச்சிறுகுடல்
Ileum	பின்சிறுகுடல்
Chyme	இரைப்பை பாகு
Villi, microirlli	குடல் உறிஞ்சிகள், நுண்குடலுறிஞ்சிகள்
Goblet cells	கோப்பை வடிவச்செல்கள்
Lymphoid tissue	நிணநீர்த்திசு
Peyer's patches	பேயர் திசுத்தொகுப்பு
Lymphocytes	லிம்போசைட்டுகள்
Crypts	கிரிப்ட்ஸ்/ மடிப்புகள்
Succus entericus	சிறுகுடல் சாறு
Ceacum	பிதுக்கம்
Colon	பெருங்குடல்
Rectum	மலக்குடல்
Vermiform appendix	குடல்வால்
Herbivorous animal	தாவர உண்ணிகள்
Symbiotic bacteria	இணைவாழ் பாக்டீரியாக்கள்
Anal mucosa	மலவாய் கோழைப்படலம்
Anal column cells	மலவாய் தூண்செல்கள்
Piles/haemorrhoids	மூலம்
Serosa	செரஸ் உறை
Muscularis	தசை உறை
Sub mucosa	கோழைகீழ் படலம்
Mucosa	கோழைப்படலம்
Visceral peritonium	வயிற்றறை பெரிடோனியம்
Submucosa plexus	கோழை கீழ் வலைப்பின்னல்
Biological catalysts	உயிர் வினையூக்கி
Parotid	மேலண்ணச் சுரப்பி
Subumaxillary gland	கீழ்த்தாடைச் சுரப்பி
Sub lingual gland	நாவடிச் சுரப்பி
Peptic cells	இரைப்பை செல்கள்
Parietal cells	இரைப்பை சுவர் செல்கள்
Falciform ligament	அரிவாள் வடிவம்
Hepatic lobules	கல்லீரல் நுண் கதுப்புகள்
Ampulla of vater	கல்லீரல், கணையப் பொது நாளம்
Mastication	மெல்லுதல்

Bolus	உணவுக் கவளம்
Peristalsis	அலையியக்கம்
lubrication	உயவூட்டுதல்
Churn	கடைதல்
Proenzyme	முன்நொதிகள்
Putrifaction	அழுகுதல்
Emulsification	பால்மமாதல்
Absorption	உட்கிரகித்தல்
Intestinal mucosa	குடல் கோழைப்படலம்
Lumen	வெற்றிடப் பகுதி
Facilitated transpot	பொருட்கள் வழி கடத்தல்
Concentration gradient	அடர்த்தி வேறுபாடு
Active transport	செயல்மிகு கடத்தல்
Passive transport	இயல்பு கடத்தல்
Bartholins duct (or) duct of riviris	நாவடிச் சுரப்பி நாளம்
Cementum	பற்கள் ஈறுடன் இணைக்கும் கடினமானப் பொருள்
பாடம் 6 : சுவாசம் (Respiration)	
Respiratory volume	நுரையீரல் கொள்ளளவு
Respirometer	சுவாச அளவி
Spirometer	ஸ்பைரோமீட்டர்
Surfactants	மேல்பரப்பிகள்
Bio-molecules	உயிர் மூலக்கூறுகள்
Respiratory disorder	சுவாசக்கோளாறுகள்
Pollutants	மாசுபடுத்திகள்
nasopharynx	நாசிப்பகுதித் தொண்டை
Glottis	குரல்வளைத் துளை
Epiglottis	குரல்வளை மூடி
Cartilaginous rings	குருத்தெலும்பு வளையங்கள்
Alveolus	காற்று நுண்ணறை
Chocking	சுவாச அடைப்பு
trachea	மூச்சுக்குழல்
Bronchus	மூச்சுக்கிளைக்குழல்
Bronchioles	மூச்சுக்கிளை நுண்குழல்கள்
Basement substance	ஆதாரப் பொருட்கள்/ அடிப்படைப்பொருட்கள்
Conducting zone	கடத்தும் பகுதி
Respiratory zone	சுவாசப்பகுதி
Pressure gradients	அழுத்த சரிவு வாட்டம்
Intercostal muscles	விலா எலும்பிடைத்தசைகள்
Thoracic chamber	மார்பறை
Inspiration	உட்சுவாசம்
expiration	வெளிச்சுவாசம்
Snoring	குறட்டை
Residual volume	எஞ்சிய கொள்ளளவு
Total lung capacity	மொத்த நுரையீரல் கொள்ளவு
Inspiratrory capacity	உட்சுவாசக் கொள்ளளவு
Expiratory capacity	வெளிச்சுவாசக் கொள்ளளவு
Vital capacity	உயிர்ப்புத்திறன்
Inspiratory reserve volume	உட்சுவாச சேமிப்புக் கொள்ளளவு

Expiratory reserve volume	வெளிச்சுவாச சேமிப்புக் கொள்ளளவு
Partial pressure	பகுதி அழுத்தம்
Partial pressure gradient	பகுதி அழுத்தம் சரிவுவாட்டம்
Dead space	பயனற்ற இடம்
Bronchitis	மார்புச்சளி நோய்
Emphysema	நுரையீரல் அடைப்பு
Reversible manner	மீள்வினைத் தன்மை
Chemosensitive area	வேதிஉணர்பகுதி
Sputum	சளி
nasal congestion	மூக்கடைப்பு
Sore throat	தொண்டை வலி
fibrosis	நார்த்தசை நோய்
Carcinogens	புற்றுநோய்க் காரணிகள்
Hypoxia	ஆக்சிஜன் பற்றாக்குறை
Heart palpitation	இதயப் படபடப்பு
Nausea	வாந்தியுணர்வு
Anaemia	இரத்தசோகை
Congenital heart disease	பிறவிக்குறை இதய நோய்
Hyperbarisim	மிகைஅழுத்தத் தன்மை
suffocation	மூச்சுத்திணறல்
Conjugated protein	இணைவுப்புரதம்
Haem moieties	ஹீம் பகுதியின் ஒரு பாதி
Respiratory quotient	சுவாசக்கெழு எண்
Cat ions	நேர்மின்அயனிகள்
Electrostatic attraction	மின்னிலைக் கவர்ச்சி
Irritants	எரிச்சலூட்டும் பொருட்கள்
Hiccups	விக்கல்
Aerobic respiration	காற்றுடைச் சுவாசம்
Anaerobic respiration	காற்றற்ற சுவாசம்
பாடம் 7 : உடல் திரவங்கள் மற்றும் சுற்றோட்டம் Body fluids and circulation	
Cardiac activity	இதயச்செயல்பாடுகள்
Cardiac cycle	இதய சுழற்சி
Blood coagulating factors	இரத்த உறைதல் காரணிகள்
Vasovagal syncope	வேகஸ் நரம்பின் அதிகரித்த செயலால் ஏற்படும் மயக்கம்
Perfusion	மேற்பரவல்
Capillary	தந்துகி
Arteriole	நுண்தமனி
Hydrostatic pressure	இரத்த திரவ அழுத்தம்
Osmosis	ஊடுகலப்பு
Arterial end	தமனி முடிவுப் பகுதி
Venous end	சிரை முடிவுப்பகுதி
Formed elements	இரத்தச் செல்கள்
Hepatic portal vein	கல்லீரல் போர்ட்டல் சிரை
Hepatic vein	கல்லீரல் சிரை
Hepatic artery	கல்லீரல் தமனி
erythropoiesis	சிவப்பணு உருவாக்கம்
Granulocytes	துகளுடையவெள்ளையணுக்கள்
Agranulocytes	துகளற்ற வெள்ளையணுக்கள்

Phagocytic nature	விழுங்கும் தன்மையுடைய
Pus	சீழ்
Inflammatory reaction	வீக்கம் ஏற்படுதல்
Cell mediated immunity	செல்வழி நோய்த்தடைகாப்பு
Macrophages	மாக்ரோஃபேஜ்கள்
Sinusoids	குழிப்பைஅடைப்பு
Antigen	எதிர்ப் பொருள்
Antibody	எதிர்வினைப்பொருள்
Blood transfusion	இரத்தம் செலுத்துதல்
Trauma	விபத்து
Meshwork	வலைப்பின்னல்
Lymph nodes	நிணநீர் முடிச்சுகள்
Inguinal	தொடைப்பகுதி
Axillaries	அக்குள் பகுதிகள்
Sub Clarian vein	சப்கிளேவியன் (அ) சிரை
Lacteals	லாக்டியல் நாளங்கள்
Vasoconstriction	இரத்தக்குழல் சுருக்கம்
Vasodilation	இரத்தக் குழல் விரிவடைதல்
Anastomoses	இருவேறு தமனிகள் இணைப்பிடங்கள்
Abdominal cramps	வயிற்றுப்புறப் பிடிப்புகள்
Venules	நுண்சிரைகள்
Uniderectional flow	ஒருதிசை ஓட்டம்
Ventricular septum	வென்ட்ரிகுலார் இடைத்தடுப்பு
Auricular septum	ஆரிகுளார் இடைத்தடுப்பு
Double circulation	இரட்டைச் சுற்று ஓட்டம்
Pulmonary circuit	நுரையீரல் இரத்த ஓட்டம்(சுற்றோட்டம்)
Systemic circuit	சிஸ்டமிக்(அ) உடல் இரத்த ஓட்டம் (சுற்றோட்டம்)
Papillary muscles	பாப்பில்லரித் தசைகள்
Pericardial space	பெரிக்கார்டியல் குழி
Pericardial fluid	பெரிக்கார்டிய திரவம்
Auriculo ventricular valves	ஆரிக்குலோ வென்ட்ரிகுலார் வால்வுகள்
Inferior vena cava	கீழ்ப்பெருஞ்சிரை
Superior vena cava	மேற்பெருஞ்சிரை
Pulmonary veins	நுரையீரல் சிரைகள்
Myogenic heart	மயோஜெனிக் வகை இதயம்
Depolariation	மின்காந்த முனைப்பியக்கம்அகன்ற நிலை
Tachycardia	டாக்கி கார்டியா
Brady cardia	பிராடிகார்டியா
Stroke volume(SV)	வீச்சுக் கொள்ளவு
Semilunar valves	அரைச்சந்திர வால்வுகள்
Heart rate(HR)	இதயத்துடிப்பு வீதம்
Cardiac output (CO)	இதயத்திலிருந்து வெளிப்படும் இரத்த அளவு
sphygmomanometer	இரத்தஅழுத்தமாணி
Pulse rate	நாடித்துடிப்பு
Atheroma	தமனிச்சுவரில் கொழுப்புப்படிவு
Hypertension	மிகையழுத்தம்
Atherosclerosis	இதய இரத்தக்குழல் அடைப்பு
Brain haemorrhage	மூளையில் இரத்தக் கசிவு
Cerebral infarction	பெருமூளைத் திசுச் சிதைவு

Myocardial infarction	இதயத்தசை நசிவுறல் நோய்
Angina pectoris	தீவிர மார்பு வலி
Rheumatoid heart disease	ருமாட்டிக் இதய நோய்
Rheumatic fever	ருமாட்டிக் காய்ச்சல்
Varicose veins	இரத்தநாளங்கள்சுருளுதல்
Embolism	தமனியில் இரத்தக் கட்டி அடைப்பு
Aneurysm	தமனி விரிசல், குருதிநாள நெளிவு
Catheter	உட்செலுத்திக் குழாய்
Scaffolding	சாரக்கட்டு, தூக்கிக் கட்டுதல்
Pump oxygenator	பம்ப்ஆச்சிஜனேட்டர் (ஆக்சிஜன்செலுத்தி)
Resuscitation	செயல் தூண்டல்
Cessation of breath	மூச்சு நிறுத்துதல்

Zoology – Class XI

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